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Edited by

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CONTENTS.

	Page
Cold Storage Effect on *Trichogramma* and on the Eggs of *Ephestia Kuhniella*, by C. B. Redman King	19
Cold Withering Experiments, by A. H. Hall and T. Glen Dickson. ...	118
Composting by the Indore Process, by T. Eden.	160
Cultivation of Shade Trees, Green Manures, and Cover Crops, by T. Eden.	93
Culture and Marketing of Tea (Review), by R. V. Norris. ...	28
Editorial Notes, by R. V. Norris.	1, 42, 116, 157
Effect of Pruning on the Occurrence of Tea Tortrix (*Homona coffearia*), by F. R. Tubbs.	146
Experiment with *Trichogramma* and *Tortrix*, by C. B. Redman King.	15
Financial Position of the Institute, by J. Forbes (Jnr.).	56
Half-Yearly Report of the Small-holdings' Officer, by R. L. Illankoon.	150
Increasing the Length of Pruning Cycles, by E. G. B. de Mowbray.	99
Manuring of Tea, by T. Eden.	61
Notes on Experimental Manufacture of Medium Grown Leaf at a Higher Elevation, by E. G. A. Palmer.	171
Notices.	41, 115, 156, 183
Plucking Individual Rows, by E. R. N. Godfrey.	179
Pruning in Relation to Estate Profits, by F. R. Tubbs. ...	4
Pruning of Tea, by F. R. Tubbs.	75
Question of Policy, by T. Eden.	4
Review of the Activities of the Tea Research Institute. by R. V. Norris.	45
Review of the First Pruning Cycle of the T.R.I. Manurial Trials, by T. Eden.	83
Some General Problems of Manuring, by T. Eden.	134
Tea Tasters' Terms, by J. Lamb.	129

EDITORIAL.

VISITORS' DAY.

Representations having been received that the *first* Wednesday in the month is inconvenient to many planters, Visitors' Day has now been changed to the *last* Wednesday. In the case of persons who may wish to visit on other days it is requested that, if possible, appointments be made. Members of the staff are frequently away on visits to estates and unless an appointment be made disappointment may be caused owing to the absence of the Officer it is desired to meet.

PRUNING EXPERIMENTS.

In the present number will be found a report of a lecture on "Pruning in Relation to Estate Profits" given by the Plant Physiologist to the Sabaragamuwa Planters' Association. The field experiments on pruning carried out by the Institute have already yielded results of very great interest which are of particular importance to tea estates in the Low-country. Some of the results were discussed at the last Conference and have already been published in *The Tea Quarterly*, 1933, **6,** page 11. Later work has confirmed and amplified these findings and fuller details will be found in the Annual Report for 1933. Meantime some of the salient points are discussed in Mr. Tubbs' article. The main fact which emerges is the great advantage resulting from the adoption of rim lung pruning at low elevations. In the Galatura experiments rim lung pruning when compared against clean pruning reduced the number of deaths after pruning by eighty seven per cent., while, in addition, the amount of pre-tipping dieback was reduced by nearly half. These results are naturally reflected in better recovery from pruning and a higher yield of flush in the pruning cycle. The explanation of this behaviour is quite simple, the basic fact being that any treatment which will leave a reasonable amount of leaf on the bush at pruning enables the bush to continue the manufacture of food supplies and, hence, recovery

is not dependent solely on the food reserves which are only too often inadequate for this purpose in the Low-country. In the case of bushes at higher elevations the food reserves, for reasons explained in the article, are almost invariably very much higher and hence dieback ceases to be of importance.

The importance of lighter forms of pruning at low elevations has been stressed ever since Gadd's discovery of the relationship between food reserves and recovery and this has led to some modification of the heavier pruning previously favoured. A cut-across, however, not infrequently leaves much less leaf on the bush than might be expected and hence is not so efficacious as a rim lung prune. Moreover, the latter has one further great advantage in that the centre of the bush can be properly cleaned out, leaving the bush less liable to attack from disease.

The figures obtained in these experiments are so striking that we trust they will receive the attention they deserve.

MANURING.

The recent improvement in the tea industry is enabling many estates to spend larger sums on manurial programmes and in this connection a word of warning is perhaps desirable. In numerous cases where applications of manure have been entirely stopped or only very small doses applied the consequent loss in fertility is already being reflected in reduced crops. It is not to be expected that this state of affairs can be immediately remedied, even where funds permit, and any attempt to restore yields too rapidly by heavy manuring is likely to be attended with very definite risks. There is little evidence that manures *when applied in reasonable quantities* have any effect on quality and in the light of the Institute's own experiments and of work elsewhere, this statement applies just as much to inorganic artificials as to organics.

On the other hand, there is ample evidence that unduly high nitrogenous manuring, resulting in too rapid and sudden forcing of growth, is detrimental to quality and this will be the case equally with organics and inorganics, the decisive factor being the *amount* of nitrogen applied and not its kind.

In cases where the above considerations are ignored and attempts made to restore yields too rapidly, it is likely that this will be done by the use of inorganics owing to their much lower cost. Should bad results follow these will be attributed, quite unfairly, to the use of inorganics as such and the old prejudice against these is likely to be revived. This would be a very unfortunate result as, properly applied, inorganics have a very definite use and unnecessary curtailment of their employment will only lead to an avoidable increase in the cost of production.

INSECT PESTS.

It is well known that many insects are attracted to light and the use of light traps is, in fact, a well-known device frequently employed in combating many of these pests.

We have received through the courtesy of a correspondent details of one of the latest and most highly developed of these devices known as the Germaine Gourdon Insect Catcher. This trap depends on the use of ultra-violet rays, the wave length of which can be readily adjusted by a simple arrangement, for it is claimed that different classes of insects are attracted by rays of different wave length, the optimum wave length varying, however, with certain climatic conditions. The apparatus is made in various forms and sizes, ranging from small sets, capable of being worked off an ordinary light point and suitable for bungalow use, to large models adapted for use in the field.

Official trials appear to have been made of this apparatus at Saintes Maries de la Mer and in the United States. In the former trial it is claimed one hundred and forty million mosquitoes were destroyed in 126 hours, while in the American test, thirty million gnats were caught in five hours.

If these figures be reliable it is clear that the efficiency of the device is of a much higher order than that of similar apparatus previously put on the market and further particulars are being sought.

ROLAND V. NORRIS.

PRUNING IN RELATION TO ESTATE PROFITS*

F. R. TUBBS.

I was particularly pleased to accept your Chairman's invitation to talk to you today, for it is giving me an opportunity to discuss the results of my Low-country pruning experiments with a number of the superintendents from the district in which they have been obtained. I would take this opportunity of again thanking the firm and agency responsible for the provision of facilities and the co-operation which has enabled the work to be carried out at Galatura.

When I selected the title of my talk today, I chose "Pruning in in Relation to Estate Profits" because the importance of the relationship has been to a large extent ignored in Ceylon.

It has always been realised that it is possible to reduce the yield and capital value of the bushes by gross errors in pruning, but what is not realised is that the value of the methods in every-day use vary to an extraordinary extent according to the elevation of the estate and the climate it enjoys. This variation renders it suicidal to use the same methods of pruning in Ratnapura as would be used in Dimbula. Yet how often has an attempt been made to do so ? In the old days, with no accurate or comparable data to act as a guide, mistakes were inevitable. It is the function of the Tea Research Institute to provide comparable data upon the effects of different treatments and it is with the purpose of giving a first instalment upon pruning—one of the many subjects which the Institute is investigating—that I am here today.

To those who are suffering from the ill-effects of treatment applied to the bushes in most cases many years ago, I recommend direct application to the Institute for advice on their particular problem. But, in addition, we are now in a position to describe the different effects that will result from the different types of pruning normally used in Ceylon.

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* Lecture given before the Sabaragamuwa District Planters' Association,

It is necessary, in order to obtain a proper understanding of what follows, to appreciate the basis of the investigations. Some among you may have been present at the Tea Conference of 1929 when Dr. Gadd showed that, in his experience, a deficiency of starch in the roots was the predisposing cause of death after pruning, and that the fungus *Botryodiplodia Theobromae* was of minor importance, merely playing a secondary part in attacking bushes already dying from physiological causes. One line of my work at Galatura and in the laboratory at St. Coombs has been the confirmation of his work and its extension to include dieback and the investigation of its effect on yield and growth.

I collected sixty-nine samples of roots from tea of approximately eighteen months after pruning from all over the tea districts by the aid of Superintendents of Estates. An examination of the total carbohydrates extractible by a standard acid extraction showed that the percentage of carbohydrates in the roots varied according to the elevation of the field of tea, and that when plotted against elevation the points tended to fall onto a straight line. This line, when statistically calculated, showed that, on the average, the percentage of carbohydrates rose from 10·13 per cent. at sea level by 0·232 per hundred feet to 26·37 per cent. at an elevation of 7,000 feet. In other words.

CORRIGENDA.

Vol. VII, Part I, February, 1934.

Page 5, line 20 for 10·13 read *11·17*.
Page 5, line 20 for 0·232 read *0·200*.
Page 5, line 21 for 26·37 read *25·17*.

heit for every thousand feet of higher elevation. The higher the temperature, the greater the rate of photosynthesis, growth, and

respiration of a plant. Photosynthesis is the process of carbohydrate manufacture, and the higher temperatures of the Low-country will speed up the process during the hours of the day in which light is available for the process. But the breakdown of carbohydrates by respiration is also speeded up—and this proceeds throughout the twenty-four hours, instead of for only about twelve hours a day. In addition, the enhanced growth rate calls for more carbohydrates to be used directly in building up leaves, stems, and roots instead of being stored up as reserves.

Thus, we see that, as a result of climatic differences, the bush at a high elevation contains within its roots ample reserves to enable its recovery from pruning, while those at low elevations do not. How can you and I, faced with the problem of making Low-country tea pay, get over this difficulty?

Manuring and cultivation have sometimes been suggested as remedies. Manures have their very distinct place in the scheme of maintaining the health of the bush, but what is wanted in the Low-country at pruning time is carbohydrates within the bush. Leaves are the organs for manufacture of these substances and it follows that, if the bush has not sufficient carbohydrates stored up by the end of its cycle to enable full and healthy recovery from pruning, it must *not* be deprived of its sole source of fresh supplies.

Leaves must be left on the bush at pruning time in such cases. I personally would adopt this procedure at any elevation below 1,500 feet above sea level. Any form of cut-across gives the desired result, but this method suffers from two disadvantages. Firstly, sufficient leaves are often not left, and, secondly, any dead or diseased wood cannot be efficiently cleaned out. Lung pruning allows of sufficient leaves being left on, and also for efficient and careful cleaning out of the interior of the bush at pruning. All of you, I expect, have seen lung pruning and by now you will be forming the questions in your mind "How many leaves should remain on the bush at pruning time" and "Have you proved beneficial results to accrue from lung pruning."

The answer to the first question depends upon the reserves the bush already possesses. At the lowest elevations well over three hundred leaves should be left. It is not accurate enough to say three or six lungs should be left, for their value depends upon the area of leaf surface upon them. But a count of the leaves left on a few bushes soon gives one an idea of the number remaining which proves a better estimate of leaf areas. At higher elevations progressively fewer leaves will be needed.

To the second query an unequivocal affirmative can be given. We will first of all take the question of the yield of flush from rim lung and clean pruned plots. The cycle of two years of my Galatura experiment will not be complete until the end of April, but it is obvious from the yields to date that pruning in such a way as to leave about two hundred leaves per bush on the lungs till about ten days before tipping has resulted in an increase of crop of over 200 pounds per acre to date. This more than compensates for the extra two or perhaps three rupees an acre required for pruning !

These results on yield are not of prime importance at the moment owing to restriction, but they will be definitely important when restriction ends. And I would lay stress here on the fact that these results were obtained in the first cycle. It is reasonable to expect that there will be cumulative effects and, if these are of any magnitude, even more striking results may be expected in the future. The continuation of the experiments, rendered possible as it is by the continued help of the firms interested, will decide the point.

Another question arises here. Is quality likely to be lost as a result of this enhanced yield ? There is no evidence to date of any such loss, and as the difference in yield appears to be due at least in part to dieback, I can see no rational reason for expecting it. I cannot conceive that keeping a bush alive instead of half killing it can adversely affect the quality of its products.

The yield of a tea estate affects both the total revenue coming in and also the cost per pound of putting the tea on the market.

But the profit available for distribution is always reduced by the amount of the expenditure required to maintain the estate in good order as a commercial proposition. It stands to reason, therefore, that if we can to some extent reduce the wear-and-tear on the bushes, which are to a tea estate what machines are to a factory, a smaller proportion of the gross profits will be absorbed in replacement and in restoring the bushes to good health. It is essential, therefore, that we should not merely look at the effect of pruning on yield, but that we should also consider its effect on the maintenance of the capital value of the plant.

In 1932 there were published in *The Tea Quarterly* figures concerning the effect of the method of pruning on the number of deaths after pruning and the amount of dieback in the Low-country. Perhaps owing to the impression that variations in pruning had little effect on yield or profits, the article caused little comment in planting circles. It was shown that the number of deaths per acre, reckoning 3,000 bushes to the acre, was one hundred and thirty four in the clean pruned plots and only sixteen in the rim lung pruned plots. These figures are sufficiently startling, but in addition we now have the benefit of data from an expermient at Galatura performed in 1933. In this experiment were observed the effects of (a) 6 lungs left on the bush either one or two months after pruning, (b) 3 lungs left on the bush for either one or two months after pruning and (c) clean pruning. Six lungs carried an average of 327 leaves, three lungs 203, while clean pruning left an average of 3 leaves.

It was found that the six lung treatment resulted in only 22·5 deaths, compared with 28·2 for three lungs and 168·6 for clean pruning per acre of 3,000 bushes. In other words, 327 leaves remaining on the bush for part of the recovery period resulted in decreasing the number of deaths by *eighty-seven per cent.*

This as is obvious, has a considerable bearing on estate profits. If we reckon replacement of a bearing tea bush to cost fifty cents per bush, the 1932 experiment showed a saving of Rs. 59/- per acre and the 1933 experiment a saving of Rs. 74/- per acre in capital value.

If you consider fifty cents per bush too generous an estimate of its value, apply any smaller value you like. A simple calculation will convince you that savings, well worth while making, can be obtained by due attention to the method of pruning used. The figures for yield and for deaths after pruning which I have given will, I hope, convince you of this, but this is not all. We have yet to consider the effect of method of pruning on the health of the bushes that survive.

After pruning, the bush may not die completely—it may suffer death of some of its frame branches only. This reduces yield, and provides entrance to disease organisms which bring in their train a whole series of losses. Measurements to date have shown that up to twelve hundred pounds of dead wood per acre may be removed after pruning and even this high figure is sometimes considerably exceeded over small areas. I need not labour the advantages of eliminating this—they must be obvious to you all. I have found that the amount of pre-tipping dieback can be reduced considerably by lung pruning. The figures obtained *per thousand bushes* were

Clean prune	236·9 pounds
3 lungs	127·3 ,,
6 lungs	109·5 ,,

The method of pruning does not appear to affect the amount of post-tipping dieback, however.

These figures, as might be expected, are reflected in the recovery after pruning. The dry weight of material removed in tipping provides an index of recovery and I have figures for this. The weight of tippings from the six lung treatments is more than double that from clean pruning, with the three lung treatment occupying an intermediate position.

It is interesting to note that there is significant evidence that if only about two hundred leaves per bush are left on the lungs they should be left on for at least two months, whereas with three hundred leaves per bush the lungs can be removed earlier

without disadvantage. The figures also effectually contradict the fear that is sometimes expressed that the growth of the lungs is prejudicial to the production of tipping shoots in the centre of the bush.

To sum up, we may, by providing plenty of leaves on the bush during the period immediately following on the pruning operation, reduce the number of deaths and the amount of dieback and increase the rate of recovery and subsequently the yield of the tea by amounts which are sufficiently great to be of considerable importance.

There has been a strong tendency during—may I call it the recent ?—depression to concentrate on manufacture to the exclusion of field works. I feel it is only by due attention to both the field and the factory that the best results can be obtained and therefore today I have endeavoured to bring before you the importance of one aspect of field works in the Low-country. I hope I have also convinced you that Agricultural Research can still do something to bring back and maintain prosperity.

In this connection I may close with a reference to an account the "Times of Ceylon" of a report by Mr. Jones, of the Thee Expert Bureau of Java. In it he says:—

"In spite of these times of depression, tea is being planted up in various other countries, and it is therefore essential that the countries which are old established in the business should spare no efforts to keep well in advance from every standpoint, so as to be in a strong position to meet competition in the future."

Let us in Ceylon take this recommendation to heart, and spare no effort, either in the field or in the research laboratory, to maintain our position in the face of future competition.

A QUESTION OF POLICY.

T. EDEN.

The pages of this journal have contained frequent references to the relative merits of inorganic and organic fertilizers. The correspondence that has ensued shows that considerable interest is taken in the matter, but that the position of the Institute in the matter of policy is by no means generally appreciated. For a number of reasons the time is opportune for the representation of the question in the light of present conditions.

There is an opinion abroad that the Institute has given an unconditional blessing to the use of inorganic manures. This is not the case; every article that has appeared has been written with a due sense of responsibility on the part of the writer and the least that is required is a similar responsibility on the part of the reader. We have numerous instances in our files of correspondents' omission to pay heed to the very important qualifications that have accompanied our statements of the general position: a tendency to jump to conclusions and to lift our recommendations out of their context. Perhaps it will be fair to accept some of the blame for this ourselves; the scientific worker is faced with the task of avoiding a too concise statement of his views and equally of avoiding the appearance of talking down to his lay audience.

It has been the aim of the Institute to consider its problems both in relation to fundamental conditions and in relation to present day needs. Throughout the depression the assistance of the Institute has been solicited in the planning of manurial policy, and in a large number of cases we have advised the use of inorganic fertilizers. The two predisposing conditions we have insisted on have been:

(a) Shortage of money,

(b) A thorough-going green manuring policy.

We have based this policy on the results of a series of experiments which now cover three years which show no superiority for

organic fertilizers. When the alternative has been put to us of either discontinuing or drastically curtailing manuring or using inorganics, we have not hesitated to say that in our view the better policy was the latter. We have taken up the position that our experiments provided a number of years' grace for hard pressed estates and that what it was not possible to recommend with the finality which scientific worker and planter alike desire, was sound and reasonable as a special policy under the circumstances and adequately supported by critical data. Rather than cut down estimates on green manuring, soil erosion prevention or other necessary works, this attitude has, it seems to us, considerable preference. Thus far we have gone and no further. Readers who will refer to articles in previous Quarterlies on "Recent Experiments on Manuring" (*Tea Quarterly*, 1933, Vol. **6,** p. 25) and "Soils, Fertilizers and the Growing Plant" (*Tea Quarterly*, 1932, Vol. **5,** p. 141) will find these reservations most carefully stated there.

Not only are the reservations stated in definite terms, but the data themselves tell their own tale. We are drawing no deductions from areas obviously overdosed with nitrogenous manures. The limit to our deductions is apparent from the fact that quantities in excess of 40 pounds N per acre have not been used. What would happen if much larger quantities were used it must be left for further experimentation to decide, but the indications are that quality would suffer irrespective of the kind of manure used.

We have never indulged in special pleading on behalf of any particular kind of manure; those who have money enough to spend wholly or largely on organic manures are assured of a good standard product very easily stored and distributed and attractive in everything but price. If nitrogen in groundnut cake could be procured at the price per unit of that in sulphate of ammonia or very near to it, it would be worth while paying the extra freight because of the gain in ease of application. The whole of the argument is about *relative values.*

To every man his own opinion, but if a man expresses that opinion he may be reasonably called upon to give his reasons and table his evidence. We have not hesitated to contest some of the reasons adduced for the superiority of organics, not because we wish to prejudge the issue, but simply because in the interests of clear and scientific thinking we could not let demonstrably wrong arguments pass. Typical of such arguments is that based on the prevalent use of farmyard manure in temperate climates. This argument ignores the very large quantities of artificials (mainly inorganic) used in agricultural rotations, and insists on confusing the properties of 'organic' artificials with those of farmyard manure. It is safe to say that a bigger gulf divides organic artificials from farmyard manure, than from sulphate of ammonia.

Whenever the results of the Institute's trials are quoted, there can always be lodged an objection that their duration is short. That we willingly concede: what cannot be conceded is that such a fact weakens the case for inorganics but not for organics. The whole of the evidence for and against these two kinds of manures rests on these trials and there is no evidence of a demonstrably reliable kind for organic nitrogen that exceeds this duration; or if there is it has not yet been produced. The popular attitude with respect to inorganic artificials has up to now been that they are (to quote an apt observer) guilty until they are proved innocent. So much must be said not in the interests of inorganic artificials, which can bide their time till a final verdict is available, but in the interests of clarity of thought.

As for the future there are two matters to consider—what the Institute can do to elucidate further this question, and what the recommendations to estates should be. The Institute is continuing the comparison of inorganic and organic nitrogens on the existing experiment. It is suppressing the cyanamide plots which are of only academic interest and in their place will put groundnut cake so as to provide an organic fertilizer of lower nitrogen content. In addition, though for scientific reasons manures like bone meal and sterilized

animal meal cannot be used on the existing experiment they are being compared with inorganic forms of nitrogen and phosphate at the Institute's sub-station in the Passara district.

With regard to manurial policy on estates, now that the deepest trough of depression is past, we would advise the use of some of one or other of the organic forms of nitrogen as an admixture with inorganics as a physical conditioner and in order to add to the bulk of the manure sufficiently to offer greater ease of distribution. There is no case for reverting to the fantastically complicated mixtures which were in vogue a few years ago. The question as to whether to go back to the old proportions of inorganic and organic nitrogen must be left to those in control. Some estates have used inorganic manures for one year only, some for two and few probably for three. The Institute's experiments will continue to give a margin of safety to those who wish to adhere to the inorganic programme *as exemplified in the aforementioned experiments*. Further than this our advice cannot go without departing from evidence and making use of speculation. It is no part of our function to encourage a taste for hypothetical speculation; on the contrary the Tea Research Institute aims at providing evidence which will make such speculation unnecessary.

Finally, in order to enliven what is in danger of becoming a very dull argument by reason of the very repetition of the pros and cons, the writer would be pleased if any who will trouble to do so will drop him a post card giving their views on the following manure mixture and saying at the same time whether their natural bias is for organics or inorganics.

Castor cake	100 lb.
Bone meal	135 ,,
Muriate of Potash	25 ,,
Sulphate of Ammonia	160 ,,
	420 ,,

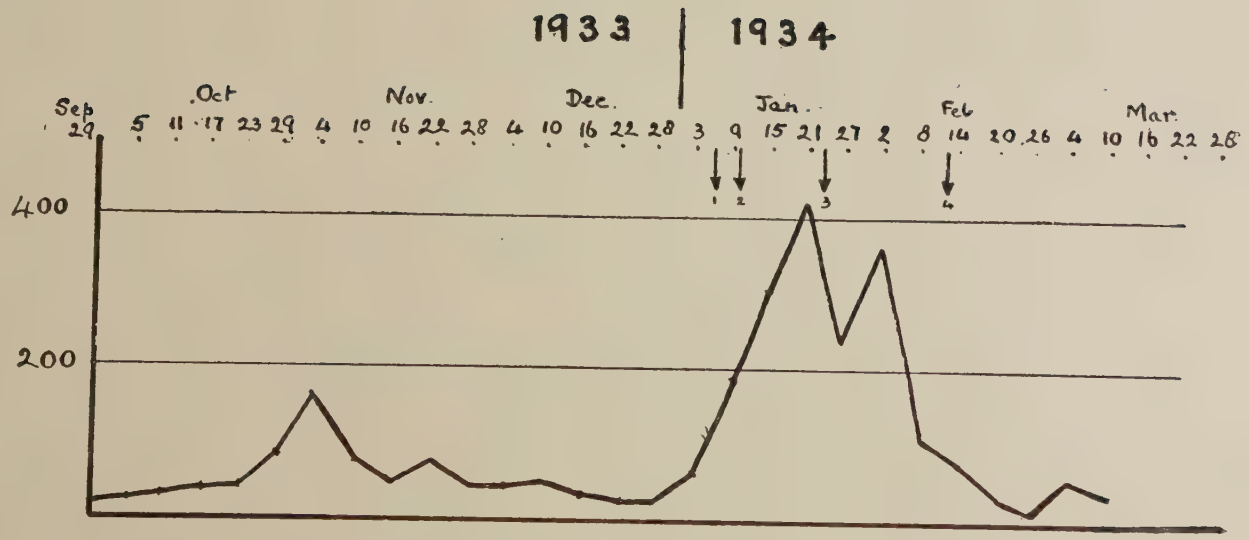

Fig 1

Graph showing the number of eggmasses per acre collected on a $4\frac{1}{2}$ acre block. The first arrow indicates where the parasites emerged; the remainder refer to the dates of examination.

AN EXPERIMENT WITH TRICHOGRAMMA AND TORTRIX.

C. B. REDMAN KING.

The object of this experiment was to determine the rate of increase and the rate of diffusion of the parasite under field conditions, Tortrix eggmasses being the hosts.

Ten plots were chosen in December, 1933, in fields where it seemed likely that there would be a sufficient population. The plots were all the same size, square in shape, consisting of fifteen rows of fifteen bushes each.

There were five treatments, each duplicated. The treatments were:—

(1) 1000 parasites liberated at the centre bush of a plot.

(2) 2000 parasites liberated at the centre bush of a plot.

(3) 1000 parasites liberated on two different bushes in a plot, situated at opposite corners, on the fourth bush of the fourth row, counting from each corner.

(4) 4000 parasites liberated at the centre bush of a plot.

(5) 1000 parasites liberated every other day, four times, at the centre bush.

Eggmass collection during the previous months indicated that there would be a rise in eggmass population in the first week in January,* and the parasites were put out on January 4th, 1934. (Fig. 1).

Freshly parasitised eggs were used and stuck on small manilla labels by means of rubber solution, experiment having shewn that this material is the simplest to use, is unaffected by rain, and does not affect the developing parasites in any way. A few inches of thin

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* See *Tea Quarterly* Vol. VI, p. 164.

wire was attached to each label, by which it was tied to an iron rod stuck into the ground through the bush, the label being a few inches above the bush.

On January 6th. the parasites emerged and had all disappeared from the labels two days later. An examination was made of all the plots on the 9th. and 10th. of January to determine what population of eggmasses was then present; no parasitised eggmasses were found on this occasion the criterion of parasitism being the heavy blackening of an egg. Parasitism resulting from the parasites put out could not show up before January 12th.

As the period of development of the parasite was found to be 18 to 20 days in the field at this time, the first examination for parasites was carried out on the 23rd. and 24th. of January, which was considered sufficiently late to show up any parasitism which had occurred since January 6th., but before any emergence had taken place.

The second examination was carried out on February 12th, and 13th. to determine the development of the first field generation.

As eggmass population declined rapidly after this, and also because the result of the last examination was almost entirely negative, no further search for parasites was made.

EXAMINATION ON JANUARY 23-24, 1934.

After the parasites emerged, a considerable increase in eggmasses was recorded but on seven out of the ten plots no parasites were recorded at all. On the other three, the following results were obtained:—

(1). A plot in which 2,000 parasites were liberated at the centre. One eggmass was found which was about 20 per cent. parasitised, and having about thirty parasites developing. This eggmass was three bushes away from, and north of, the centre, say about ten feet distant.

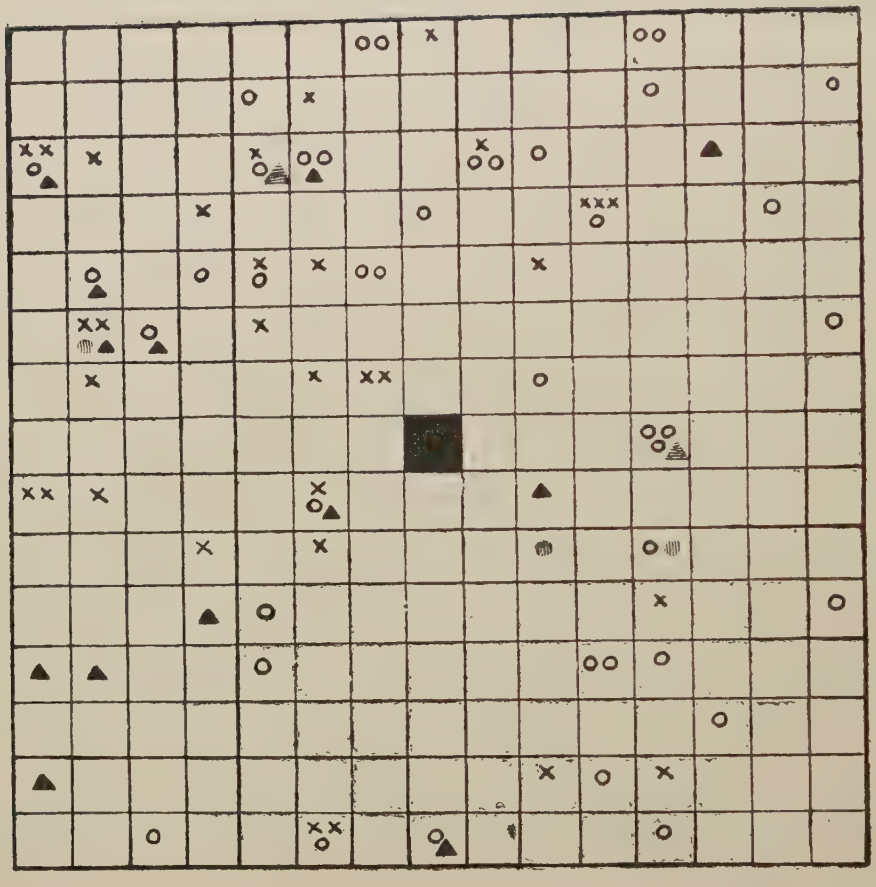

Fig. 2

Diagram of one of the plots on which parasites were found to have established themselves. The squares represent bushes; at the centre one, which is blacked, were liberated 4,000 parasites.

A X indicates an eggmass found at the first examination.

A O indicates an eggmass found at the second examination.

A ▲ indicates an eggmass found at the third examination.

The shaded symbols indicate eggmasses which were parasitised. The one on the extreme left showed 20% parasitism, the remainder 5%. These eggmasses were all about average size, containing 130-140 eggs.

(2). A plot in which 2,000 parasites were liberated on two different bushes. One parasitised eggmass was found on a bush on the same diagonal as the parasite cards, next to the centre bush. This eggmass was parasitised to the extent of 15 per cent., with about twenty developing parasites in it.

(3). The third plot was one in which 4,000 parasites were placed at the same time on the centre bush. In this plot were found three eggmasses parasitised, two of them 5 per cent. each, and the other 20 per cent. Two of them were a short distance away on the south-east of the centre bush, the 20 per cent. mass being westwards six rows away, a distance of about 25 feet.

Figure 2 is a diagram of this plot, each small square representing a bush. A cross indicates an unhatched eggmass at the inspection of January 9th and 10th, for which a circle does duty at the examination on January 23rd and 24th. A triangle shows eggmasses laid between these dates and February 12th and 13th.

The result of the experiment is extremely disappointing. Only five eggmasses in three plots were parasitised by the parasites liberated in them, and in two of the plots they failed to reproduce themselves. In the third plot, illustrated in Fig. 2, a few parasites were found at the last examination and represented a decrease on the previous generation. While sensational results were not anticipated, such a poor showing was not expected.

The weather, on the whole, was favourable. On January 7th, there was a heavy storm in the afternoon, during which $2\frac{1}{2}$ inches of rain fell in $2\frac{1}{2}$ hours. This may account, at least in part, for the failure of the parasites put out, with the exception of two plots, in which 1,000 parasites emerged on the 6th, 8th, 10th, and 12th of January. Thus, 3,000 parasites in each of these plots escaped the storm, and yet no case of parasitism was recorded in either plot. Up till January 24th the weather was cloudy, with little or no wind, with the atmosphere fairly humid, but not excessively so—weather extremely favourable to the little parasites. On the evening of the

24th it was a little windy, and on the following evening about 2 inches of rain fell, but it was not heavy. After this, the weather was fine, but windy until the last examination.

It may be stated here that observations on liberated parasites made at other times showed that the parasites could quickly gain a footing in the field, and that they were able to parasitise about half the eggmasses present to the extent of 60 per cent. or so. The maximum parasitism in an eggmass did not exceed 70 per cent. The experiment described above therefore shows that there may be a considerable element of uncertainty attending the utilisation in the field of these parasites. The experiment should be repeated, using up to 100,000 parasites at a time in an attempt to assess the value of these insects

The following table shows the number of eggmasses available about the time of liberation of the parasites, and at the second and third examinations (only unhatched eggmasses being counted):—

		1st. examination	2nd. examination	3rd. examination
1st Treatment	plot 1	23	23	0
	,, 2	10	9	1
2nd ,,	,, 1	26	21	3
	,, 2	24	9	0
3rd ,,	,, 1	28	76	7
	,, 2	21	15	0
4th ,,	,, 1	30	45	4
	,, 2	11	2	1
5th ,,	,, 1	23	17	0
	,, 2	12	18	4

COLD STORAGE EFFECT ON *TRICHOGRAMMA* AND ON THE EGGS OF *EPHESTIA KUHNIELLA.*

C. B. REDMAN KING.

INTRODUCTION.

In order to raise a large stock of *Trichogramma* parasites for use in the field, a refrigerator becomes necessary for storing them until required, and the question arises, what is the effect of cold storage on them ? The experiments following describe the data obtained to find out the effect of time on subsequent emergence and the best time after blackening to refrigerate the parasitised eggs. As the eggs used were those of *Ephestia kuhniella*, the larvae of which web together the surrounding unhatched or parasitised eggs, and feed on them, some experiments were designed to find out if cold storage would kill them, and if so, whether the parasite found them acceptable for parasitism and whether parasites could successfully develop in them and emerge.

CONDITIONS OF THE EXPERIMENT.

Owing to the fact that current was not available for about 9 hours a night, and for an additional 9 hours on Sunday, a box consisting of four thickness of $\frac{5}{8}$ inch Celotex was constructed round the cupboard part of the refrigerator, which was a domestic type of about six cubic feet capacity. The fluctuation during the 24 hours was about 6°F. the minimum being 38°F. and the maximum (on Sundays) 45°F. at the bottom of the refrigerator. The parasite experiments were carried out at these temperatures, and those connected with the hatching of eggs were done at the centre, where the temperatures ranged from 32°F. to 38°F.

Parasitised eggs were stuck on cards and placed in glass lidded tins, and unparasitised eggs were kept in stoppered tubes, to avoid desiccation.

ERRORS IN THE EXPERIMENTS.

As batches of eggs up to 1,000 were used, it was too laborious to count an exact number every time, and a measure was used instead. This measure consisted of rings of various sizes glued to a piece of glass. Eggs were placed in one of the rings in such a way that one layer just covered the surface of the glass. They were then counted, and the ring given a round number, the nearest 100 to that given by the count. The rings actually used were labelled 1,200 and 400, and a count of 1,000 was made by taking 1,200 of the larger ring, and subtracting 200, as measured by half the smaller ring. In measuring 500, 400 were taken by the 400 measure and 100, counted, added.

In measuring five lots each of 1,000 and 500 eggs by the above method, the following counts were obtained:

100 Measurement	500 Measurement
978	406
1,027	411
1,013	394
1,006	397
1,014	418

The difference between the errors in the two sets of figures is found not be significant, and the error derived from the ten figures is $\pm$ 1·91 per cent.

Another source of error arises in dealing with parasitised eggs. These are used instead of active adults for the sake of convenience when a batch of eggs is to be parasitised. In order to arrive at some idea of the fertility of the parasite, it is necessary to know the number of females used, as well as the number of eggs parasitised by them. A count of 14,897 parasites used in experiments gave 10,027 females which is very close to two-thirds of the total and this figure is used for establishing the number of females in each lot of parasitised eggs.

INSECTS AND APPARATUS.

The eggs of the meal moth, *Ephestia kuhniella*, were used in all the experiments, and *Trichogramma evanescens* was the parasite. In all experiments dealing with the effect of low temperatures on parasitised eggs, except No. 7, the latter were put in the refrigerator the day before the parasites were due to emerge.

EXPERIMENT 1.

To determine emergence of parasitised eggs stored in the refrigerator for different periods of time (=T).

Five lots of 1,000 parasitised eggs were placed in the refrigerator, one lot being removed every seven days.

TABLE I.

T	No. of parasites emerged	Emergence %
7 days	980	98
14 ,,	940	94
21 ,,	721	72·1
28 ,,	474	47·4
35 ,,	208	20·8

EXPERIMENT 2.

As for experiment I, but beginning after 24 days, nine lots being removed at intervals of five days.

TABLE II.

T	No. of parasites emerged	Emergence %
24 days	390	39
29 ,,	232	23·2
34 ,,	136	13·6
39 ,,	55	5·5
44 ,,	38	3·8
49 ,,	8	·8
54 ,,	9	·9
59 ,,	None	0
64 ,,	None	0

EXPERIMENT 3.

This experiment was on the same lines as the foregoing, but carried further to find out what effect the storage had on the fertility of the parasites that emerged.

TABLE III.

1 T	2 Parasites emerged	3 No. of ♀♀ (Col. 2x⅔)	4 % Emergence	5 No. of progeny	6 No. of eggs parasitised per ♀	7 No. emerged from Col. 5	8 % Emergence
5 days	993	662	99·3	4,473	6·75	4,430	99
10 ,,	991	660·7	99·1	3,684	5·57	3,630	98·5
15 ,,	968	645·3	96·8	4,377	6·77	4,319	98·6
20 ,,	922	614·67	92·2	3,732	5·74	3,689	99
25 ,,	804	536	80·4	2,045	3·81	2,022	98·8

A further generation was developed, 1,000 parasitised eggs being taken from those in column 5, except the last, in which 500 were taken:—

TABLE IV.

1 T	5 No. of 1st generation	9 No. of parasitised eggs taken	10 No. of ♀♀ (Col. 5x⅔)	11 No. of progeny	12 No. of eggs parasitised per ♀
5 days	4,473	1,000	667	3,820	5·73
10 ,,	3,684	1,000	667	5,116	7·65
15 ,,	4,377	1,000	667	4,560	7
20 ,,	3,732	1,000	667	5,145	7·7
25 ,,	2,045	500	333	2,664	8

EXPERIMENT 4.

A repetition of Experiment 3, using 500 parasitised eggs instead of 1,000.

TABLE V.

1 T	2 Parasites emerged	3 No. of ♀♀ (Col. 2x$\frac{2}{3}$)	4 % Emergence	5 No. of progeny	6 No. of eggs parasitised per ♀	7 No. emerged from Col. 5	8 % Emergence
7 days	492	328	98·4	2,640	8·05	2,627	99·5
14 ,,	494	329·3	98·8	1,895	5·75	1,874	98
21 ,,	477	318	95·4	2,246	7·06	2,212	98·4
28 ,,	419	279·9	83·8	1,984	7·1	1,963	99·1
35 ,,	172	114·67	34·4	704	6·14	693	98·6
42 ,,	58	38·67	11·6	112	2·9	110	98·2
49 ,,	10	6·67	2·0	0	0	0	0
56 ,,	9	3	1·8	16	1·78	14	87·5

As before, the parasites were taken through another generation. the results of which are given in Table VI.

TABLE VI.

1 T	5 No. of 1st generation	9 No. of parasitised eggs used	10 No. of ♀♀ (Col. 9x$\frac{2}{3}$)	11 No. of eggs parasitised	12 No. of eggs per ♀
7 days	2,640	500	333	2,494	7·5
14 ,,	1,895	500	333	2,574	7·73
21 ,,	2,246	500	333	1,118	3·35
28 ,,	1,984	500	333	1,807	5·42
35 ,,	704	704	469$\frac{1}{3}$	2,660	5·56
42 ,,	112	112	74$\frac{2}{3}$	241	3·22
56 ,,	16	16	10$\frac{2}{3}$	51	4·7

In experiments 3 and 4, the progeny columns 5 and 11 are obtained by submitting 6 times the number of fresh eggs to the number of parasitised eggs shown in columns 2 and 9 respectively.

The percentage of emergences expected from parasitised eggs allowed to develop and emerge without hindrance is over 98 per cent., which is that shown by over a million parasites reared under laboratory (but not including refrigeration) conditions. Column 8 in experiments 3 and 4 show that behaviour in subsequent generations after refrigeration is scarcely affected. Emergence after a period in cold storage is definitely affected, however, and although it may remain at over 90 per cent. for about 3 weeks, it begins to fall rapidly afterwards. In comparing experiments 1 and 2 with 3 and 4, it will be seen that the decline of emergence takes place sooner in the first two than in the last two. It happened that the parasitised eggs in the first two experiments were raised at a temperature of about 84°F. and in the second two experiments at a room temperature of about 70°F. and this may explain the subsequent differences of behaviour. If this is so, then it would appear that the parasites can stand refrigeration better after being bred in the lower temperature than in the higher one.

EXPERIMENT 5.

This and the succeeding experiment were undertaken to find out the effect of cold on *Ephestia* eggs.

The centre of the refrigerator was used, where the temperature was 32 to 38, and 9 lots of 100 *Ephestia* eggs were stored there in stoppered tubes over varying periods.

TABLE VII.

1	2
T	% hatched
7 days	80
14 ,,	24
21 ,,	4
28 ,,	0
35 ,,	0
42 ,,	0
49 ,,	0
56 ,,	0
70 ,,	0

In this experiment, four weeks at the temperature indicated was evidently sufficient to kill the eggs.

EXPERIMENT 6.

The above experiment was repeated, using twenty lots of 500 (counted) eggs each, and two lots of each were removed every seven days, one lot being for the observation of hatching, the other being used for parasitism; emerging parasites being used. The results are shown below:—

TABLE VIII.

1 T	2 No. hatched	3 % hatched	4 No. parasitised added	5 No. ♀♀ (counted)	6 No. of eggs parasitised	7 No. of eggs parasitised per ♀
7 days	387	77·4	75	50	312	6·2
14 ,,	291	58·2	72	50	314	6·3
21 ,,	164	32·8	70	50	307	6·1
28 ,,	55	11	70	50	103	2
35 ,,	36	7·2	70	50	320	6·4
42 ,,	8	1·6	70	50	305	6·1
49 ,,	1	·2	70	50	212	4·4
56 ,,	1	·2	70	50	236	4·7
63 ,,	1	·2	70	50	182	3·6
70 ,,	0	0	70	50	189	3·8

Although experiments 5 and 6 were conducted under similar conditions, and the details of the results are a little at variance, it is sufficiently well indicated that temperatures a little above freezing are inimical to the survival of the embryo. After a week, not more than 80 per cent. or so survive, and there is a progressive mortality corresponding with age in the refrigerator. In the second experiment, the percentage of caterpillars hatching was quite small after six weeks, and these were markedly less vigorous than those hatching from unchilled eggs. Moreover, the eggs after this time were still normally attractive to the parasites for oviposition purposes, and gave rise to normal parasites.

When an egg has been successfully parasitised, it is only possible to know this, without dissection, by the change in colour of the egg. This change takes place rather less than half the way through the cycle. Thus, if the cycle takes twelve days to complete, the egg will turn dark about the fifth day. It seemed of interest to find out whether emergence was affected by submission to cold storage at different periods of the life cycle. For convenience, parasitised eggs are usually stored the day before emergence is due so that they may be expected to give rise to active parasites shortly after removal.

EXPERIMENT 7.

Ten lots of 500 eggs which were turning black were stuck on cards. One lot was at once put in the refrigerator, and another lot was put in each succeeding day until parasites began to emerge from the remainder. In this experiment each lot was kept for the same length of time in cold storage, namely 14 days, before removal. At the time the experiment was carried out, the cycle was fifteen days, and the eggs began to turn dark on the 7th day, on which day the first card was put in cold storage, the temperature being 38° to 45°F.

The results are shown in the following table:—

TABLE IX.

1 Age when put in cold storage	2 Time in refrigerator	3 Time until emergence after removal from refrigerator	4 % Emergence	5 Cycle in days excluding storage period
7 days	14 days	8 days	98·8	15
8 ,,	,,	7 ,,	99·0	15
9 ,,	,,	6 ,,	99·0	15
10 ,,	,,	5 ,,	98·4	15
11 ,,	,,	4 ,,	99·2	15
12 ,,	,,	3 ,,	98·6	15
13 ,,	,,	2 ,,	99·0	15
14 ,,	,,	1 ,,	99·4	15
15 ,,	,,	0 ,,	99·0	15

From the last card put into the refrigerator, one parasite had already emerged.

It will be seen that it makes no difference to the emergence whether the developing parasites are stored at the beginning of the darkening period or at the end, or indeed at any time in between, if the period of storage is a fortnight. The experiment also shows that this period of storage does not increase the normal period of development.

Note.—The symbol "♀" is used to express "female" in the tables.

THE CULTURE AND MARKETING OF TEA*

(REVIEW).

The general scope of this interesting book, as is indicated in the preface, includes first, a general account of the tea plant and its treatment, secondly, the chemistry and pharmocology of tea, thirdly, a more detailed description of the methods employed in the different tea countries and lastly, a section on the British tea trade.

The author was for many years attached to the Tocklai Experimental Station, and hence is particularly well qualified to give a critical survey of the tea industry and the methods employed therein. It is, therefore, a little disappointing that so much of the book is purely descriptive in character, and that in many of the statements made it is difficult to ascertain what is based merely on tradition, what on theory and what on ascertained facts. We feel sure readers would have welcomed a more direct expression of the author's personal views on controversial matters and a clearer indication of the results of modern research in tea.

The section dealing with conditions in North-East India is naturally much fuller and more authoritative than the chapters dealing with tea in other countries, and the methods there described provide an interesting field of comparison for planters in other areas. It is unreasonable to expect the same degree of accuracy in the chapters dealing with countries other than India and there are in fact a good many misstatements in the section dealing with Ceylon which we hope will be amended in future editions of the book.

Workers in Ceylon will not agree with the author's classification of Ceylon soils which is too rigid in character. Both in regard to composition and physical properties, the bulk of Ceylon soils do not conform either to laterites or podsols. It is unfortunate that soils from Matale and Badulla should have been taken as types. Both

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* "The Culture and Marketing of Tea" by C. R. Harler. London, Oxford University Press, 1933.

these areas possess marked and widely distributed limestone belts and the soils have lime values which are quite unrepresentative of Ceylon as a whole.

Again, though instances are known of soils with a pH value above 6 on which tea grows well, these are quite exceptional and there is no justification for the differentiation made in this respect between the behaviour of Ceylon and Indian soils.

Passing on to tea growing and cultivation we find the statement that "the young bush may be formed by collar pruning". The implication that this is the normal Ceylon practice is very wide of the mark. Again, many of our readers will not agree with the conclusion, however much it may apply to Indian conditions, that soil disturbance *per se* has little effect on yield. On the contrary evidence accumulates of the beneficent effect of more thorough cultivation.

In view of the importance attaching to the effect of treatment, manurial and otherwise, on quality, one would particularly have appreciated a more critical treatment of this question. Unfortunately here tradition seems to have been taken at face value.

Only brief reference is made to pests and diseases of tea in Ceylon but one cannot but be surprised at the statement that Diplodia is the most serious root disease. It is some years now since it was clearly shown by the work of Gadd that failure to recover from pruning in the Low-country is primarily due to a deficiency of food reserves in the bush at the time of pruning. According to this view the invasion by *Botryodiplodia* and other saprophytic fungi is purely secondary, occurring after the death of root tissues, in other words the trouble is of physiological origin. Later work has confirmed the correctness of this view and indicated methods of treatment which prevent or greatly reduce such losses. This is not the only instance in which recent work carried out outside India appears to have escaped the attention of the author.

Passing to manufacture, we think the advantages of controlled withering are somewhat unduly discounted and, judging from Ceylon experience, that many of the defects attributed to such systems are largely due to misuse of the facilities provided.

With reference to fermentation it is a little surprising to read in regard to Ceylon that fermentation racks in cool districts are frequently placed on a breezy verandah with the leaf thinly spread, perhaps not more than half-an-inch thick. Whatever may have happened in the past, particular attention is now paid in Ceylon to fermentation conditions and great care taken to protect fermenting leaf from conditions which may lead to any drying of the leaf which can only result in an uneven fermentation.

The book concludes with a section on tea tasting and chapters on the marketing of tea. A useful glossary is given of the various terms used by tasters and the plea for greater uniformity in this respect will meet with a sympathetic response in Ceylon.

In calling attention to certain inaccuracies and defects it is not our wish to decry the general value and interest of the book as a whole. On the contrary, it provides the most comprehensive survey of tea in all its bearings at present available and we are confident the book will be very widely read in Ceylon and other tea producing countries. For this very reason, however, it is desirable that in future editions such errors should be rectified.

ROLAND V. NORRIS.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD ON 2-12-33.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held in the Victoria Commemoration Buildings. Kandy, on Saturday, the 2nd December, 1933 at 10-30 a.m.

Present.—Mr. R. G. Coombe (Chairman), the Hon'ble the Financial Secretary (Sir Wilfrid Woods, C.M.G.), Messrs. B. M. Selwyn, D. H. Kotalawala, M.S.C., John Horsfall, Jas. Forbes (Jnr.), I. L. Cameron, D. T. Richards, A. W. L. Turner (Secretary), R. R. Muras (Accountant), and by invitation Dr. Roland V. Norris (Director, T. R. I.). Mr. J. W. Ferguson (Visting Agent), and Mr. Gordon Pyper.

Absent.—The Director of Agriculture, Messrs. C. E. Hawes, J. C. Kelly, and Col. T. G. Jayewardene, M.S.C.

1. Notice calling the Meeting was read.

The Late Governor Sir Graeme Thomson.—The Chairman said it was with feelings of sincere regret that he referred to the sad and sudden death of their late Governor, Sir Graeme Thomson.

By his untimely death the Empire had lost an able Administrator and this Colony a real and true friend in the truest sense.

He would ask them to signify their consent that the Tea Research Institute of Ceylon should join with the many who have already sent messages of sympathy to Lady Thomson in her great loss.

The vote of condolence was passed, all members standing.

2. (a) The Minutes of the Meeting of the Board of the Tea Tea Research Institute of Ceylon, held on 5th August, 1933, were confirmed.

(b) *Board Meeting.*—The Chairman apologised for having had unavoidably to postpone the Meeting from the 10th November, and hoped that members were not inconvenienced thereby.

(c) *Members of the Board of the T.R.I.*—The Chairman welcomed Mr. John Horsfall on his return from leave, and thanked Mr. Gordon Pyper for acting during that period. He also welcomed Dr. Norris, who had resumed duties as Director after $8\frac{1}{2}$ months' leave.

3. JUNIOR STAFF PROVIDENT FUND.

The Chairman asked for confirmation of the action of the Trustees of the Junior Staff Provident Fund in having deposited funds with the Ceylon Savings Bank.

The Board confirmed the action of the Trustees.

4. SENIOR SCIENTIFIC STAFF.

(a) *Director, T. R. I.*—The Chairman announced that Dr. Norris, the Director of the Institute, resumed his duties as from the 25th October, 1933.

(b) *Mycologist—Dr. C. H. Gadd's Leave.*—The Chairman said that he had sanctioned Dr. Gadd's leave subject to confirmation of the Board. He would proceed on leave as from the 13th December, 1933, to the 22nd October, 1934, ten months, eight days in all, six months, 23 days on full pay and three months, 16 days on half pay.

His agreement expired on the 30th June, 1934, and he hoped that all members would agree to its renewal. Dr. Gadd had been very seriously ill and he was sure that they would all congratulate him heartily on his return to health and express their appreciation for the work he had put in whilst acting as Director.

He would also like to thank Mr. Eden and Mr. Tubbs for the work they put in during Dr. Gadd's illness and until the return of Dr. Norris.

It was agreed to grant Dr. Gadd's leave and to renew his agreement for a further period of five years as from the 1st July, 1934.

(c) *Entomologist—Mr. C. B. R. King's Leave.*—This Officer's application for $8\frac{1}{2}$ months' leave as from the 4th April, 1934, was considered and sanctioned.

(d) *Tea Technologist.*—The Chairman said that the Director had under instructions inserted an advertisement in "Nature".

He asked the Director to explain the position.

The Director reported that in accordance with the instructions given him by the Board he had advertised the appointment and also approached various Universities and Chemical Institutes. Twenty-three applications had been received and from these a short list of five candidates prepared. Four of these candidates had been interviewed by a Selection Committee consisting of Mr. Stockdale, Mr. Horsfall and himself, while he had subsequently interviewed the fifth candidate alone.

As a result of these interviews the appointment of Mr. J. Lamb, M.Sc., was recommended. He was a Biochemist, Honours Graduate of London, with a year's training at Cambridge and had held a Government scholarship in Trinidad where he went for further training. He has been favourably reported on and had been selected by the Colonial Office for a Colonial appointment. He was 24 years old and the impression was that he was a very suitable type. He had not had any special mechanical training but there seemed no doubt that he would prove to be a suitable man.

Mr. John Horsfall supported all that the Director had said.

It was decided that immediately the State Council agreed to the maintenaance of the 14 cents cess for 1934, a cable should be sent to Mr. Lamb offering him the appointment.

5. ST. COOMBS ESTATE.

(a) *Broken Mixed Teas.*—The Chairman said that the Superintendent had written to say that this type of tea was accumulating in the factory and if not disposed of soon might result in a larger stock being stored in the factory than could be covered by the current insurance policy. He had consulted the Chairman of the Ceylon Estates Proprietary Association who recommended that the Superintendent should continue to sell as much of this type of Tea as possible to the labour force, at a price not below 22 cents. Whenever tea was sold to local caddies the receipt should be endorsed to the effect that the sale had been effected without coupons. Any Broken Mixed Teas not disposed of in this manner, he thought should be destroyed as it would not be wise for the Institute to sell at the door.

Mr. Cameron, Mr. Richards and Mr. Ferguson all strongly deprecated the tea being sold locally except to the labour force.

Mr. Cameron suggested that as much of this grade as possible be sold to the labour force at not less than 15 cents per lb. and the balance sold in Colombo as uncouponed tea.

This was agreed to by 4 votes to 3.

(b) *Tea Samples.*—The Chairman said that Mr. Cameron had suggested that although they could not agree to send samples of St. Coombs teas to individual estates or companies, samples of each invoice might be forwarded to the Ceylon Association in London, who would doubtless arrange for any persons interested at that end to see the teas. Mr. Richards said that he had mentioned in the Circular that a $\frac{1}{4}$-lb. packet would be quite sufficient and could be sent to any well-known London Tea Broker who would he felt be only too pleased to let the Institute have a report and retain the samples in his office.

The Meeting agreed to this latter suggestion.

(c) *Letter from the Agricultural Chemist re Pruning Experiments.*—The Director said that the Experimental Sub-Committee had approved suggestions made by the Agricultural Chemist for the temporary use of one of the factory withering lofts for drying and weighing prunings obtained from the manurial plots. Information would in this way be obtained as to the influence of treatment on wood production, etc. The Insurance Company had intimated in writing that they had no objection to the proposals.

The Board confirmed the recommendation of the Experimental Sub-Committee.

(e) *Manuring Programme.*—The Board also adopted the Experimental Sub-Committee's recommendation that the present manuring programme be continued for a further period of one year.

6. CLOSER LIAISON BETWEEN BLENDERS, DISTRIBUTORS AND PRODUCERS OF TEA.

The Chairman said that a copy of a letter written in this connection by Sir Theodore Chambers to Mr. G. K. W. Stewart was sent to each member of the Board on the 27th October.

It was decided to wait a further communication from the Ceylon Estates Proprietary Association before taking any action on the matter.

7. LEASE OF CADDY AT ST. COOMBS.

On the Chairman's recommendation the Board agreed that the lease of the caddy which expires on the 14th January, 1934, should be renewed for a further period of three years, to the present tenant.

8. ADVERTISING THE "TEA QUARTERLY."

The Chairman said that since the last Meeting the Secretary had been in communication with the Indian Tea Association who supplied the names of 26 Agency Houses, out of which only three wished to be registered to receive the publications. The Secretary of the United Planters' Association of Southern India too was approached on this matter and he very kindly inserted a special paragraph in the "Planters' Chronicle" drawing attention to the Institute's Publications.

The Chairman added that he had requested the Secretary to order sufficient copies of the Annual Report from Tocklai issued by the Indian Tea Association for distribution amongst the members of the Board.

9. CHAIRMAN'S RESIGNATION.

Mr. Coombe said that he would ask them to accept his resignation as Chairman of the Board.

He had asked Mr. Jas. Forbes (Jnr.) if he would take up the duties and he was glad to say that he had agreed to do so. It would, he suggested be more convenient for Mr. Forbes to relieve him after the Special Board Meeting to be held on the 13th January, 1934, to consider the Estimates.

He would therefore ask the Board to agree to his proposal that Mr. Forbes take the Chair after the General Meeting to be held on the 13th January. They were he considered extremely fortunate in that Mr. Forbes had consented to take up the duties of their Chairman.

Mr. Forbes thanked the Chairman and said that if they so wished he was ready to take up the work and hoped that he would have the Board's full co-operation.

This was agreed to unanimously.

The Director said that he would like to be given an opportunity of expressing the regret of both the Senior and Junior Scientific Staffs of the Institute that Mr. Coombe was vacating the Chairmanship and to express their deep appreciation of the very sympathetic consideration they had received from Mr. Coombe throughout his period of office.

The Meeting terminated with a vote of thanks to the Chair.

A. W. L. TURNER,
Secretary.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD ON 13-1-34

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held in the Ceylon Chamber of Commerce Rooms, Colombo, on Saturday, the 13th January, 1934, at 10-30 a.m.

Present.—Mr. R. G. Coombe (Chairman), the Director of Agriculture, Col. T. G. Jayewardene, V.D., M.S.C., Messrs. B. M. Selwyn, C. E. Hawes, D. H. Kotalawala, M.S.C., Jas. Forbes (Jnr.), I. L. Cameron, J. C. Kelly, F. A. Bond, A. W. L. Turner (Secretary) and by invitation Dr. Roland V. Norris (Director) and Mr. J. W. Ferguson (Visiting Agent).

Absent.—The Hon'ble the Financial Secretary and Mr. A. G. Baynham.

1. Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 2nd December, 1933, and of the Finance Sub-Committee Meeting held on the 22nd December, 1933, were confirmed.

3. FINANCE.

The Statement of Accounts as at 30th November, 1933, which had been sent to each member of the Board on the 21st December, 1933, was adopted.

4. MEMBERS OF THE BOARD OF THE INSTITUTE.

(a) Announced that the Planters' Association of Ceylon had re-elected Mr. Jas. Forbes (Jnr.) for a further period of three years as from the 3rd December, 1933.

(b) Announced that Mr. John Horsfall had tendered his resignation and the Planters' Association of Ceylon had elected Mr. A. G. Baynham to serve in his place. The Chairman in proposing a very

hearty vote of thanks to Mr. Horsfall for the very great amount of work he had done on behalf of the Institute mentioned the fact that Mr. Horsfall had been a member of the Deputation which visited Tocklai before the Institute was inaugurated and had been closely connected with the Institute ever since and had acted as Chairman of the Board for a period. This vote of appreciation was cordially agreed to.

(c) The Chairman welcomed Mr. F. A. Bond who had been nominated by the Ceylon Estates Proprietary Association to act during the absence of Mr. D. T. Richards who had proceeded on 3 months' leave as from the 20th December, 1933.

5. COMMITTEES.

(a) *Experimental Sub-Committee.*—Mr. R. G. Coombe, previously an ex-officio member as Chairman, was re-nominated to the Sub-Committee on vacating the Chair, Mr. John Horsfall who had resigned from the Board was also re-nominated.

(b) *Finance Sub-Committee.*—Mr. A. G. Baynham was elected *vice* Mr. John Horsfall.

The following Sub-Committees were formed:—

(1) *Buildings Sub-Committee.*—The Chairman, T. R. I., the Director, T. R. I. and the Visiting Agent.

(2) *Medical Sub-Committee.*—The Chairman, T. R. I., the Director, T. R. I., and Mr. J. C. Kelly.

6. SENIOR SCIENTIFIC STAFF.

Tea Technologist.—Announced that Mr. T. Lamb, the newly-appointed Tea Technologist was sailing from Liverpool on the 19th instant and will therefore be due in Ceylon early in February.

7. JUNIOR STAFF, T. R. I.

Mr. E. L. Keegal—Assistant to the Biochemist.—Announced that Mr. Keegal having been appointed to the Coconut Research Station had resigned his appointment with the Institute as from the 18th January, 1934.

Mr. J. W. Reith—Field Assistant.—Announced that Mr. Reith had been appointed Field Assistant, Grade II with effect from the 2nd January, 1934.

Mr. D. L. Nicol—Field Assistant.—Announced that Mr. Nicol having been appointed Superintendent of the Rubber Research Institute's Estate had resigned his appointment as from the 15th January, 1934, Mr. Reith had been appointed to take his place.

8. ST. COOMBS ESTATE.

The Visiting Agent's Report.—The Report which was sent to each member of the Board under cover of Circular No. A.1/34 of the 9th instant was adopted without any comments.

9. SMALL-HOLDINGS OFFICER'S REPORT.

The Chairman said that a copy of this report had been sent to each member of the Board under cover of Circular No. A.2/34 of the 9th instant. He said that it appeared to him from this report that the Small-Holders were looking after their estates and that Mr. Illankoon was doing very good work. He suggested that the Board should consider the appointment of an additional officer next year.

The Report was considered satisfactory.

10. ANY OTHER BUSINESS.

The Director reported that he had received an offer from a Firm to supply free of cost for experimental purposes certain plant. Such a plant would enable further experiments to be carried out and he had informed the manufacturers that they would be glad to accept it.

The plant is to be returned when the experiments were concluded.

The Board confirmed the Director's action.

11. CHAIRMAN OF THE BOARD.

Before vacating the Chair, Mr. R. G. Coombe expressed his thanks to the Board and to all Members of the Staffs at St. Coombs and Kandy for the assistance he had received during his term of Office. He stated that now that the Board had agreed to erect the

four Junior Staff Bungalows, that he had practically seen the building programme which he had originally suggested, completed.

Mr. Jas. Forbes (Jnr.) then took the Chair and thanked the Board for having elected him thereto.

Mr. Hawes proposed that a very sincere vote of thanks to Mr. R. G. Coombe should be recorded in the Minutes.

This was unanimously agreed to.

The Director expressed thanks to Mr. Coombe on behalf of the Scientific Staff.

Mr. Coombe having returned thanks, the Meeting terminated.

A. W. L. TURNER,
Secretary.

NOTICES.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcomed but the Staff may not be free to show them round. Such visitors, on arrival at the Factory, are requested to ask for the Teamaker.

St. Coombs Estate is reached by taking the turn-off opposite culvert marked 28/10 on the Nanu Oya-Talawakelle main road. A signpost has been erected at the turn-off.

Publications.—Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not to the Director's Office.*

ROLAND V. NORRIS,
Director.

EDITORIAL.

TEA RESEARCH INSTITUTE CESS.

The proposal that the Tea Research Institute Cess should be maintained at 14 cents until the 31st December 1938, when the matter would be further considered, was discussed at the first meeting of the newly-constituted Board of Agriculture held at Peradeniya on May 10th. It is satisfactory to record that the proposal was unanimously supported by the Board, so that it has now received the full approval of the Ceylon Association in London, the Ceylon Estates Proprietary Association, the Planters' Association of Ceylon and the Board of Agriculture. The question will shortly come before the State Council and in view of the strong support given by the interests concerned it is hoped the matter will be decided at an early date.

Reviews of the Institute's work and of its financial policy which were given by the Director and the Chairman at the meeting of the Board of Agriculture are reprinted in this issue.

TEA MANUFACTURE.

In recent years various devices have been put on the market designed to replace to a greater or less extent the ordinary rolling process. The general principle behind these machines is that the leaf is cut or crushed and it is claimed that in addition to a saving of time and labour, better liquors can be obtained. Trials of these devices in Ceylon have, in general, given disappointing results. In a few cases some improvement in liquor has been noticeable but this has been more than offset by a loss in quality and appearance. This is not surprising when it is considered that the leaf after passing through

such machines is necessarily treated as though it were of a homogeneous nature. In fact this is far from being the case, the mass being a mixture of cut particles of fine leaf, coarser leaf and stalk. These naturally ferment at a different rate and the result is a mixture of which considerable proportions must be either under or over-fermented. Mixed infusions are thus obtained accompanied by a marked loss in quality. Moreover no true grading is obtained by such methods. The latter is of importance and is a point to which too little attention is frequently given.

At this time of year particular attention is desirable in connection with the moisture contents of teas at the time of packing. It is surprising to find amongst the large number of samples examined by the Institute quite a high proportion which contain an excessive amount of moisture. Such teas naturally do not keep well and are inclined to go off during transit and storage.

It is still not sufficiently recognised that tea when discharged from the drier picks up moisture with great rapidity if left exposed in a damp atmosphere. Such conditions often obtain during picking over.

Final firing unless carried out with care is often quite ineffective, many samples containing practically the same moisture content before and after final firing. The usual cause of this is that the tea is passed through the drier too quickly and does not have time to attain a temperature sufficient to drive off the surplus moisture.

The only real safeguard is for moisture determinations to be carried out in the factory as a matter of routine. A simple set of apparatus designed for this purpose was described in *The Tea Quarterly*, 1932, Vol. 5, p. 59. Sets with an electrically heated oven can also be obtained. Not only does such an apparatus enable proper control to be maintained over the finished tea but with it tests can readily be made of the performance of the drier and Superintendents can thus satisfy themselves that the latter is working efficiently and economically.

PRUNING CYCLES.

We are glad to publish in this number an article contributed by M. E. G. de Mowbray on the length of pruning cycles which we think will be of general interest. Such articles are always welcome though it is to be understood that the fact of publication does not necessarily imply that the Institute endorses the opinions expressed.

GERMAIN GOURDON INSECT CATCHER.

In the last issue of *The Tea Quarterly*, reference was made to the Germain Gourdon Insect Catcher for which very high claims have been made. We now understand that trials of this apparatus have been carried out in Mauritius and that so far these have not proved satisfactory.

ROLAND V. NORRIS.

REVIEW OF THE ACTIVITIES OF THE TEA RESEARCH INSTITUTE OF CEYLON.*

ROLAND V. NORRIS.

DIRECTOR.

My object this afternoon is to present to you a brief review of some of the activities of the Tea Research Institute. I am sure you will appreciate that in the short time at my disposal I can only cover a very small portion of the ground, and that I shall, therefore, have to omit altogether reference to a great many problems which we are investigating, confining my attention to a few of major importance and of more immediate practical interest.

It is not within my province to speak on the financial requirements necessary for the successful continuation and development of our work as this matter will be dealt with by the Chairman of the Board who is to follow me. In this connection I only wish to stress with all possible emphasis that it is impossible for a systematic and well-arranged programme of work to be arranged unless our probable financial resources for at least three or four years ahead can be foreseen. Continuity is an essential factor in research, particularly in agricultural research in which experiments in the field play a conspicuous part, and it is useless to arrange and lay down such experiments unless reasonably certain that funds will permit of these being carried on continuously for a reasonable number of years and that adequate staff will be available for their conduct and control. As examples of the disorganisation resulting from financial uncertainty I need only point out that last year the appointment of a successor to Dr. Evans, our former Biochemist, was held up for six months and that we are now again placed in a similar position in regard to an Entomologist. I am sure that point will be appreciated by those here today and I feel confident that this meeting will give its full support to the proposals which the Chairman of the Board has to make.

* Address given at the inaugural meeting of the Central Board of Agriculture on May 10, 1934.

Though the Institute was set up in 1925 no staff was recruited till 1926 and it was only in the middle of that year that a temporary laboratory was acquired in Nuwara Eliya. It is fair to say that it was not till the beginning of 1927 that work really started. The staff then comprised, beside the Director, a Mycologist, an Entomologist and a Biochemist. An Agricultural Chemist was recruited in October 1927 and a section of Plant Physiology was formed in 1930. It was not, however, until the end of 1930 that the laboratories at St. Coombs were available.

The work of the Institute thus falls into two well-defined stages, the first from 1927-1930 with headquarters at Nuwara Eliya, when the staff were without any facilities for permanent field investigations and with very limited facilities even for laboratory work, and the second from 1931 onwards when the Institute had acquired its own estate at St. Coombs and had generally speaking adequate means for both laboratory and field work as well as a tea factory available for manufacturing experiments.

It is necessary to remind you of this because during this first period it was inevitable that work had to be of a preparatory nature and largely confined to the collection of fundamental data and to the more theoretical aspects of tea research. This was naturally of less immediate practical interest to the planter but was a necessary foundation for later work at St. Coombs.

To illustrate what I mean by preparatory work I will give one example. The final test of any cultural treatment must always be made in the field. A survey of the literature dealing with field experiments in tea in Ceylon and elsewhere at once showed, however, that but little was known of the errors inherent in such experiments and that little attention had been paid to field technique with the result that much of the previous work was of limited value owing to the fact that adequate precaution had not been taken to ensure that the accuracy of the experiment was great enough to distinguish between differences due to the treatment applied and those due to other variable factors.

It was essential, therefore, that before permanent field experiments were laid down, the technique of such work should be exhaustively studied. Actually this involved nearly two years' work. It may have appeared to many planters that this was of little practical interest. Actually it was of paramount importance as the results obtained enabled us, when land was available at St. Coombs, to lay down immediately field experiments which it may fairly be claimed have an accuracy considerably in excess of any similar work carried on elsewhere. The errors associated with such experiments can now be accurately assessed and, in consequence, the conclusions drawn from the results obtained can be accepted with a confidence that would otherwise have been wanting.

I do not, however, propose to go into further details of such preliminary work but shall pass on to describe our present organisation and indicate some of the results which have been obtained

The work of the Institute may be roughly classified under three major headings:—

(a). Laboratory investigations for the collection of fundamental data and designed to elucidate the theoretical basis of the various factors involved in the cultivation and manufacture of tea.

(b). Field and factory experiments designed to test out theories based on the above work and to bring these into a form capable of practical application.

(c). Advisory work to estates based on the results so obtained.

The policy behind all laboratory and field experiments is essentially the principle of team work, any problem being attacked simultaneously from as many angles as possible. Take, for example, a manurial experiment designed in the first place to examine the effect of different amounts of nitrogenous manures. This would be primarily the responsibility of the Agricultural Chemist. But the treatment given may effect the *quality* of the made tea and this aspect of the case would be investigated by the Biochemist. Similarly the

treatment may influence the susceptibility of the bush to insect and fungus attacks, necessitating the intervention of the Entomologist and the Mycologist. The fullest co-operation between the different divisions is, therefore, essential and this is ensured by the fact that all major experiments are most fully discussed and criticised, both before the experiment is begun and throughout its progress, by an Experimental Committee. This ensures, not only that the experiment is designed on the best lines possible, but also that secondary issues are not lost sight of. In other words the experiment is organised to yield the maximum amount of information with the least expenditure of time, labour and material.

Field experiments again are not confined to St. Coombs. It was from the first realised that, in view of the very varying conditions of elevation and climate under which tea is grown in Ceylon, work on many problems would have to be repeated at different centres. This will eventually lead, when finances permit, to the starting of small sub-stations at two or three centres. While no *permanent* sub-stations have yet been formed, thanks to facilities placed at our disposal, work has been continuously in progress during the past two years in the Ratnapura District, at Peradeniya, and in Passara, in addition to work on small-holdings in the Gampola area. We have in fact four officers continuously engaged away from St. Coombs.

Of the many problems which awaited our investigation one of the most pressing was that of pruning, particularly pruning in the low-country. As you are aware very severe losses are incurred in the low-country due to the failure of bushes to recover from pruning. It was formerly considered that these deaths were due to a fungus disease of the roots commonly known as *Diplodia* root disease. In 1927, however, it was noticed by Dr. Gadd, the Institute's Mycologist, that such failure to recover from pruning was closely associated with a lack of food reserves in the bush at the time of pruning. The tentative suggestion was made, therefore, that the problem was possibly a physiological one and that the presence of the fungus was accidental or at any rate only secondary. On this basis

lighter forms of pruning were advocated. Subsequent work lent further support to the above theory and hence when in 1930 a Plant Physiologist was added to our staff, an investigation of pruning was immediately taken up as a major line of investigation.

These investigations have consisted in the comparison of three different types of pruning, a clean pruning, a cut-across and a rim-lung pruning, and have been carried out at three different elevations, viz. St. Coombs, Peradeniya and at Galatura in the low-country. At St. Coombs, the effect of time of pruning is also under investigation.

Amongst many points of interest which have arisen from these particular experiments, the most striking is the very clear proof obtained of the great advantages resulting from the use of rim-lung pruning at low elevations in place of severer types of pruning. The essential feature of rim-lung pruning is that a considerable number of leaves, say two to three hundred, is left on the bush at pruning. The bush is thereby enabled to continue its manufacture of food supplies and recovery is not solely dependent on the food reserves which, as is well known, are often quite inadequate in the low-country. The results obtained at Galatura show that rim-lung pruning, when compared against a clean prune, has reduced the number of deaths after pruning by no less than eighty-seven per cent. and the saving on this head alone amounted to more than Rs. 70/- per acre. But this is only part of the story. Not only is the number of actual deaths reduced but in the case of surviving bushes, the amount of pre-tipping dieback is reduced by nearly fifty per cent. This is reflected in larger bushes and a considerable increase in yield.

A cut-across also represents a lighter form of pruning but this not infrequently leaves much less leaf on the bush than might be expected and for this reason is less efficacious than a rim-lung prune. The latter has, however, one further great advantage, in that the centre of the bush can be properly cleaned out and snags and unhealthy wood removed.

Any method which can reduce the amount of dieback after pruning is likely to have further results of major importance, for the snags thus formed afford ideal conditions for the entrance to tea bushes of *Calotermes* and foci from which wood rotting organisms can work. The results obtained by Mr. Tubbs are therefore of first class interest, not only in their immediate application but also in view of their ultimate bearing on the health of low-country tea.

I must pass on now to another type of work—manurial experiments.

The necessity for economy in estate work imposed by the conditions of the last two years has been reflected in the number of enquiries which have been received in regard to manurial practice. In the Annual Report for 1932 the view was expressed that but little risk attached to the use of the cheaper inorganic nitrogenous manures in place of organics, provided these were used in reasonable quantities and combined with a liberal use of green manures. This view was based on the results of the manurial trials laid down at St. Coombs which had then been in progress for two years. The third year of this experiment, completing the first pruning cycle, has confirmed in every way the findings already recorded. Once more no significant difference in yield has resulted when comparing the effect of Blood Meal, Ammonium Sulphate and Cyanamide, nor has any difference in quality been noticeable between the teas treated with organic and inorganic nitrogen respectively. As in the two previous years no effect has been produced by the addition of potash.

The experiment is being continued but the results already obtained, extending as they do over three years, give a very clear answer to enquiries as to the relative effects of organic and inorganic nitrogen and have undoubtedly been of great service to estates and enabled very large economies to be effected by the substitution of cheaper and less complicated manures for the mixtures formerly in use.

There is little evidence, in short, that manures, *when applied in reasonable quantities*, have any effect on quality and this applies just as much to inorganic manures as to organics.

On the other hand, there is no reason to doubt that unduly high nitrogenous manuring of any type, resulting in a sudden forcing of growth, is detrimental to quality; in other words the decisive factor is the *amount* of nitrogen applied and not its kind.

The manurial experiment at St. Coombs has been confined to the question of nitrogen and potash. Recently a similar experiment has been started in the Passara area. Here, however, the effect of phosphoric acid will also be studied as well as the influence of the time of application of the "pruning mixture".

Soil fertility is closely connected with the physical conditions of the soil. The Institute has continually stressed the importance of this question and advocated a great use of green manures and cover crops. Apart from actual fertility such practice has of course an important bearing on soil erosion. Experiments on the establishment and treatment of bush green manures and cover crops are, therefore, being conducted. The chief difficulty is to find a suitable cover for up-country conditions. A promising species at present being investigated is *Trifolium subterraneum*, the subterranean clover. This has a moderate root system, is drought resistant and has successfully survived a severe south-west monsoon.

Amongst high shade, *Calpurnea aurea*, a South American species, seems particularly promising, while *Hakea saligna* may be useful in wind belts. The latter has been used in South India to supplement *Grevillea*.

Passing on to diseases and pests of tea, the Mycologist, in addition to advisory work generally in regard to fungus diseases and their prevention, has been particularly concerned with the disease known as Witches Broom which in the opinion of many persons is becoming much more prevalent. In this connection, however, there is probably a certain amount of confusion. Accumulated evidence points more and more to the conclusion that the term "Witches Broom" is applied to a variety of symptoms which may arise from very different causes. The term is analogous to the medical term "fever" which describes the *condition* of the patient but which is by no means of a specific

character. Many specimens sent in to the laboratory as Witches Broom cases are not really so and it is, therefore, likely that the increase in incidence is not really as great as sometimes supposed. In spite of such a reservation it must be admitted, however, that on certain estates the "disease" is spreading and is of considerable importance. As has been already pointed out in *The Tea Quarterly* there is a considerable resemblance in many respects between the symptoms of Witches Broom and those of the disease known as Tea Yellows in Nyasaland. Investigation of the latter disease has shown quite clearly that it is produced by a deficiency of sulphur in the soil and can be cured by remedying this condition.

Experiments have, therefore, been carried out by the Mycologist during the past year to see whether Witches Broom is due to a similar cause. It need only be said here that the results obtained indicate that the two diseases are evidently not identical in so much as sulphur treatment has had no beneficial effect on Witches Broom. The specific cause therefore remains obscure. It seems probable, however, that similar symptoms may sometimes arise from such diverse causes as severe wood rot, the very slow attack of a root disease, or the presence of slab rock in the soil or even from adverse climatic conditions as was seen in the Kandapola district. In the latter case the conditions cleared up quickly when normal weather was experienced.

The main problems facing the Entomologist have been Tortrix and Nettle Grub. In regard to Tortrix attention has been focussed chiefly on biological methods of control, chiefly through the egg parasite *Trichogramma*. The breeding of this parasite on the large scale has presented many difficulties. Most of these have been overcome except the question of cost. Unfortunately this last factor seems likely to be decisive, more particularly as field trials with the parasite have shown that under the conditions so far experienced its efficiency is extremely low. Work which has been proceeding simultaneously in other countries with this parasite has in most cases led to a similar conclusion and it therefore appears probable that other methods will have to be tried.

Work on Nettle Grub has been carried out at the temporary substation in Passara. Wilt is probably the main natural controlling factor, while under artificial measures soap spraying is the most convenient. Success depends on the attacks being dealt with before large areas are concerned. Spraying under these conditions combined with the regular collection of cocoons has greatly reduced both the area attacked and the intensity of such attacks. The pest has thus been checked but by no means eliminated.

As in the case of Tortrix a search is being made for parasites capable of dealing with Nettle Grub. In this connection I may remind you that in 1930 an application was made to the Empire Marketing Board for a grant to finance a comprehensive survey of insect pests and their parasites in Ceylon. Negotiations for such work were well advanced when the closing down of the Board's activities unfortunately prevented such assistance from being forthcoming.

The future of our Entomological work is causing much concern. The agreement of our present Officer expires in December and it is clear that this cannot be renewed unless the finances of the Institute are placed on a more permanent basis. No one can contemplate without anxiety, however, any relaxation of entomological research. Not only do the pests to which I have referred require further investigation but there are at least two other problems of outstanding importance to be considered—I refer to Termites and Shot-Hole Borer.

We are fortunate in having in the Department of Agriculture an officer who has made a special study of Termites and when the Institute was started it was arranged, and it was in my opinion a most satisfactory arrangement, that work on Termites in tea should still be dealt with by Mr. Jepson. I should like to take this opportunity to express on behalf both of the Tea Research Institute and of tea planters in general our appreciation of the extremely successful work which Mr. Jepson has carried out on our behalf. Unfortunately other problems now occupy a good deal of Mr. Jepson's time and it may well be that the Institute will be called upon to take over a

portion of this work. Be this as it may shot-hole borer remains as a problem which in itself calls for the retention of our full entomological staff, and I sincerely trust this meeting will endorse the view that this should be done.

I now come to the question of tea manufacture. The subject is so wide however it is quite impossible for me in the time left at my disposal to review the work we have carried out.

Detailed investigations have been made and are continuing on every aspect of manufacture. Such work naturally includes a study of the composition of the leaf and the influence on this of season, climate and cultural treatments. Similarly close attention has been given to the conditions of withering, rolling, fermentation and firing and the effect of modifications in these processes on the made tea.

Much of the data thus collected has already been published and valuable recommendations in regard to manufacture were summarised in Bulletin No. 9 of the Tea Research Institute which has I think received wide recognition from the Industry.

I should like to say a word however about future development in manufacturing experiments.

In addition to examining existing processes, it is most desirable that the Institute should be in a position to test out new inventions and processes in tea manufacture. Work in this direction has been hampered by lack of funds as considerable expense on plant and equipment would have to be incurred.

It is hoped, however, that arrangements will shortly be completed enabling us to commence an investigation of electrical withering. There can be no doubt that withering is one of the least satisfactorily controlled parts of tea manufacture and any arrangement that can offer an improvement in this direction at reasonable cost deserves close attention.

The research activities of the Institute lead up to and form the basis of our advisory work. The average number of enquiries received during the year is nearly 2,000, while about 150 visits are annually paid to estates by members of the staff.

In addition, the Institute maintains a special officer for advisory work amongst Small-Holders. During the past year this officer visited 108 small-holdings and carried out demonstrations on 53 of these. Repeated visits were paid to each village and every effort made to see that methods recommended were actually adopted and tried out. In addition to demonstrations, meetings of small-holders have been held when tea cultivation in all its aspects has been discussed. In view of the success of this work it is intended to appoint next year a second officer to work in another area.

The Annual Report of the Institute for 1933 has just been published and to this I must refer you for details of our other activities.

I believe that the results already obtained are of great value and I am confident that if the Institute is not unduly hampered by lack of funds or other restrictions, the work it can do will be of lasting benefit to the Industry.

THE FINANCIAL POSITION OF THE TEA RESEARCH INSTITUTE.*

JAMES FORBES (JNR.)
CHAIRMAN OF THE BOARD.

The Tea Research Institute of Ceylon is dependent for its revenue from its estate and from an export tax on tea, and the latter is, of course, the most important source of income. This export tax is fixed at 10 cents per 100 lbs. of tea exported by Ordinance No. 12 of 1925, which is the Ordinance which provided for the establishment of a Tea Research Institute.

At the request of those bodies which represent the tea industry this export tax was increased from 10 cents per 100 lbs. to 14 cents per 100 lbs. tea exported for three years, from January, 1931 until December, 1933, by an amending Ordinance passed towards the close of 1930, and the reason for this request was that the then income was insufficient to meet the essential extensions of the research organisation, and for their proper functioning.

During 1933 a control of exports of tea came into force and for that year curtailed the export of tea from the Island by 15 per cent. of its ordinary normal production, and this, you will appreciate affected the revenue of the Institute considerably. In point of fact the loss of income in 1933 due to restriction for nine months was some Rs. 47,000/-. The Board therefore approached the State Council (having received the assent of the bodies concerned) with a view to having the export tax maintained at 14 cents per 100 lbs. for the present restriction period, but this was agreed to by the Council for 1934 only, and the matter is to come up for revision again shortly.

Before approaching the State Council or the Associations interested the Board, realising that the control of exports and its concomitant reduced Cess would seriously affect its revenue, appointed a Sub-Committee to go into the question of finance and re-organisation, and that Committee's report formed the basis of the request for the

* Address given at the inaugural meeting of the Central Board of Agriculture on May 10, 1934.

maintenance of the Cess at the 14 cents rate when application was made to the State Council in December, 1933.

The Planters' Association of Ceylon, the Ceylon Estates Proprietary Association and the Ceylon Association in London, together with the Small-Holders' representative on the Board, approved of the report of this Sub-Committee, but the Low-Country Products Association suggested certain amendments which the Board was unable to accept at that time.

Subsequent events have, however, enabled the Board to meet, almost in their entirety, all the then criticisms of the L. C. P. A. and I trust that we shall therefore be enabled to meet the present situation with a united front.

Before going into a detailed statement of the finances of the Institute I must explain that for the purposes of the necessary capital expenditure and purchase of an estate, the Board borrowed a sum of one million rupees from Government in 1928, and this is to be repaid in 25 annual instalments for both capital and interest repayment by a fixed annual sum of Rs. 78,227/-. This is a first charge on the revenue of the Institute and is placed on fixed deposit monthly immediately revenue is remitted by the Treasury. We have been criticised in certain quarters for shewing a reserve for redemption purposes in our balance sheet, but this criticism arises from an improper appreciation of the facts. The only reason why any kind of redemption reserve appears in our balance sheet is that the Government financial year ends in September (when our annual payment is made), whereas our financial year ends at the end of December, and hence three months' deposits towards the next loan payment have accumulated.

The Board's financial policy is, (1) to maintain the Institute and Staff at such a level as to enable the work to be carried out with full efficiency and with the maximum benefit to the Industry, including the small-holder; (2) to set aside annually a reasonable sum to cover depreciation of plant, buildings, etc.; and (3) from revenue to set aside and accumulate a sufficient liquid general reserve to meet future capital expenditure.

No. 1 requires no explanation from me, but I may be permitted to say a few words on the two reserves.

Taking the depreciation reserve first, whilst the Institute was in its infancy it was only possible to make book entries for depreciation, but I think you will agree that successful researches in tea manufacture are almost certain to result in improved factory design and in improved machinery, and it will be necessary for the Institute to lead the way in applying the results to commercial practice. Although the factory and machinery and equipment is of modern design, alterations, additions and reconstructions will be necessary to test out the practical value of discoveries made by research, and for this reason the Board's aim at creating a cash reserve for this purpose must be considered sound finance, and the actual rates of depreciation which have been allowed are, in my opinion, on the low side.

Turning to tht General Reserve, the object of this is to provide means for all new capital requirements, and it will be appreciated that the usual channels available to ordinary estate companies for such purposes are not open to the Institute. There are on St. Coombs approximately 65 acres of patna land suitable for opening in tea and capital will be required in 1938, when the existing restrictions on opening land in tea are removed, for that purpose. One loft of the factory still requires tats and other requirements will arise though difficult to foresee. It seems probable that it will be necessary as research work progresses, to obtain and experiment with new types of machines and equipment, and it appears essential that the application to commercial practice of results emanating from research should not be held up for lack of funds for the purpose. An efficient General Reserve is therefore required not only to provide means to supply visible capital requirements, but for purposes which cannot at present be foreseen accurately, and I think you will agree here also that the policy of the Board in this direction is sound.

Turning to the future and our forecasts therefor, we have estimated for the Cess to be maintained at 14 cents per 100 lbs. tea exported until the end of 1938 and I am glad to be able to state that

the Planters' Association of Ceylon, the Ceylon Estates Proprietary Association and the Ceylon Association in London have all unanimously agreed at recent meetings to the Board's proposal in this connection. We have estimated that the burden of restriction will be gradually lifted, and have taken the figures as 10 per cent. for 1935, 7½ per cent. for 1936, 5 per cent. for 1937 with full crop from April 1st, 1938. Profit from the estate has been placed as at Rs. 20,000 for 1935 and Rs. 25,000/- for 1936 to 1938. And lastly, provision has been made for the retention of the Scientific Staff on existing lines, except that provision has been made for an additional Small-Holdings Officer from 1935. The latter expansion was strongly supported in the debate which took place in the State Council last December when the Cess was passed for this year.

With regard to the Senior Scientific Staff, when the 1933 forecast was made it appeared that even with a 14 cents Cess it would be impossible to retain the services of an Entomologist, but things have improved, profit from the estate has increased and the probable incidence of restriction lightened, so, although we are without an officer in this department at the moment through the State Council having allowed us the 14 cents Cess for one year only, we have been able to include him in the 1935 forecast without making any additional application for funds to the Industry.

The matter of the retention of an Entomologist has recently received the close attention of the Board, as, by not employing an officer in this department it could carry out a restricted programme of work on a 13 cents Cess from 1935 to 1938, although this would mean a reduction of revenue of some Rs. 94,000/- for the period. Many important pests of tea await investigation, of which shot-hole borer may be mentioned, and after weighing up all the considerations the Board decided that it would be taking an undue risk and lacking in its duty to the Industry if it did not recommend to the bodies concerned the retention of this important link in the administration, and its decision has been unanimously upheld by the main Associations concerned.

Taking the estimates of revenue to be as accurate as can be framed at the present juncture, and maintaining the efficiency of the Institute on economical and sound lines, it is foreshadowed that by the end of 1938 there will be a sum of Rs. 121,000/- available under the heading General Reserve. Of this sum an amount of Rs. 88,000/- for capital expenditure on opening up the estate, etc., will be required immediately, leaving a balance of only Rs. 33,000/- for future unforeseen capital expenditure, which cannot be regarded as excessive.

Recently I had the pleasure of escorting the Minister for Agriculture and Lands round the Institute and in course of conversation upon the subject of its finances he asked me for an assurance that in the event of our estimates of revenue not being fulfilled, we would not come to the State Council with a further request, and I was readily able to give him that assurance for two reasons. Firstly, my estimates have been framed with very great care, and secondly, I could not do so without the backing of the Industry, which I would not get.

But on the present occasion I submit that I have outlined to you a policy which is based on very sound financial proposals and which have the unanimous backing of the whole Tea Industry of this Island behind them, and for these reasons I apply for your approval of my application to the State Council that the Cess be retained at 14 cents per 100 lbs. of tea exported until the end of 1938, whereafter the matter can come up for further revision. In doing so I feel that it is needless for me to stress to a body such as this the absolute necessity of having this matter settled for long periods ahead.

THE MANURING OF TEA.*

T. EDEN.

A reasoned system of manuring for any crop should take into account the nature of the plant from which it comes, the climatic and other environmental conditions under which it grows, and the purposes to which the harvested produce or its manufactured counterpart is to be put; on all these points tea has features which add interest and complexity to the problem of deciding the best method of preserving and adding to the fertility of the soil in which it grows, by means of natural or artificial manures.

Tea is a perennial crop restricted severely in growth by drastic pruning operations recurring at intervals of from one to five years, and is cultivated entirely for leaf. Only the youngest shoots are plucked, and as many as fifty harvests a year may be taken. According to climate and altitude it may be in continuous production or have seasonal resting periods. It is cultivated in climates ranging from tropical to temperate, but a rainfall exceeding 50 inches and reasonably well distributed is necessary. The upper limit of precipitation is indefinite, but tea thrives in places where the annual rainfall is between 200 and 300 inches. Furthermore, the quality of the crop is of equal consideration to its quantity, and although the subsequent manufacture of the leaf intimately affects this quality, the potential character of the marketable product is to a large extent decided before the leaf leaves the bush.

A tradition of manuring embodying these considerations has gradually been built up, and the present position is one in which past history, present economic conditions, and the slow accumulation of scientific knowledge are in a state of continual readjustment.

HISTORICAL ASPECTS.

Any attempt to describe manurial practice must take some account of past history; Ceylon will be chiefly used as the example,

* Reprinted by the permission of the Clarendon Press, Oxford, from *The Empire Journal of Experimental Agriculture*, 1933, Vol. 1, pages 297-306.

but India and Java have passed through parallel stages, and divergences will be noted in their place.

The cultivation of tea was marked in the first place by a thoroughgoing exploitation of natural resources. Land under virgin forest was cleared and planted, and for a considerable time no thought was given to manuring. In Ceylon this period was shorter than elsewhere because tea was a comparatively late arrival and superseded coffee when disease destroyed the earlier industry. A questionnaire circulated in 1896, and answered by sixty representative correspondents, showed that at this date manuring was a novelty, but that the practice was spreading on old coffee estates; it was some time before occupants of virgin land learned their lesson from the older cultivators [1]. At this time it was admitted that crop increases were assured by manuring, and there was no preponderating fear that harm would result either to the permanent health of the bush or to quality of the made tea. The sources from which manure was drawn were inevitably local, and oilseed cakes and bones from India were chiefly used in the proportions of four parts of cake (castor seed) to one of bones (*loc. cit.*). Applications were irregular and not more frequent than every other year.

During the ensuing ten years there was a marked expansion in manuring. Nitrogen, as always, was the chief manurial constituent, and organic forms were predominant. Mann [2] reports that in 1907 no sulphate of ammonia was used by the tea industry of North India and that only 40 tons of superphosphate (made locally) could be traced. In Ceylon both these manures had obtained a footing but the quantities did not exceed 500 tons. Fashions in nitrogenous manures changed according to supply, demand, and price, and import data list varying quantities of castor, groundnut, rape, and mustard cakes.

The manner of this introduction of artificial manures is of considerable interest because later the belief arose that nitrogen in these (organic) forms was more steadily available than that supplied by 'soluble artificials', and was better for preserving quality. In the

absence of large industrial centres that could produce the more highly manufactured inorganic products it seems probable that there was a considerable *post hoc, ergo propter hoc* element in the birth of this hypothesis.

The next decade, which closed at a time when war influences were being felt in the fertilizer industry, saw the introduction of a large variety of fertilizers, though local material remained predominant. In particular, inorganic manures were being imported at competitive prices and, in consequence of trials and demonstrations by the research stations of India and Java, they became an important factor in manurial schemes. In India and Ceylon, superphosphate, basic slag, and sulphate of ammonia were enjoying considerable popularity at this time, as shown by Hope's qualitative review of the manurial situation [3] and Bruce's compilation of import figures for Ceylon [4]. The latter figures refer to all the visible supplies, no matter on what crop they were used, but they reflect the position as regards tea to this extent, that the only serious competitor for manures at this time was rubber, with an acreage, in 1917, of only half that devoted to tea.

The war threw back fertilizer distributors on to local supplies because of the restriction in shipping tonnage, so that not only did total imports suffer but organic nitrogen temporarily resumed its sway. This disturbance was followed immediately by a slump in both tea and rubber in 1920-1, but by 1927 a phenomenal boom in tea had arrived. Within the last two years world economic conditions have had their effect on tea. The accompanying figure,* taken from a recent survey of nitrogen imports [5], shows the general trend of supplies. Bearing in mind the fact that many rubber estates have been out of cultivation for four years, the latter years may well be taken to reflect the manurial position of tea. Nitrogen imports are still equivalent to those before the boom, and sulphate of ammonia is the most important individual fertilizer in use. In India and Java

* Omitted here as it was published in *The Tea Quarterly*, 1933, Vol. 6, p. 93.

the popularity of inorganic nitrogen is greater than in Ceylon, and the latest information shows that these two countries have almost entirely adopted this kind [6].*

Hand in hand with the increased use of artificial manures there has been an increase in green manuring. Starting in the form of loppings from shade trees, progress has been steadily maintained till at the present time leguminous bush crops and some ground cover are in addition commonly interplanted with the tea. The advocacy of Bamber [7] and Wright [8] in Ceylon and of the research stations in North India and Java has played a large part in establishing green manuring as a general policy. There is no doubt of the gain to soil conservation that has resulted from the use of green manures, though there has been a tendency to exaggerate their potentiality as a conserver of nutrients, because it has commonly been assumed that the whole of the nitrogen returned to the soil is bacterially-fixed nitrogen. Java is the leader in all forms of green manure; India makes use of both cultivated crops and naturally-growing herbage; Ceylon is still largely insistent on clean weeding.

A subsidiary method of manurial conservation is that of burying tea prunings. Formerly, much woody tissue was buried, which not only complicated the soil nitrogen cycle, but was instrumental in spreading root-diseases. For a time a lively controversy was maintained between the advocates of burying and of burning, respectively [9]. It is now usual either to fork in the soft green shoots or to mulch the prunings and beat off the dried leaves for subsequent burial. Except in areas of severe root-disease no epidemic from this cause seems to occur.

THE PRESENT POSITION

Neglecting the disorganization caused by current economic conditions, tea is generally manured at least annually, but the pruning cycle is taken as the unit. In Ceylon custom demands two types of

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* I am indebted to Dr. J. J. B. Deuss, late Director of the Proefstation voor de Thee, Java, for many points regarding practices in Java.

mixture, a pruning mixture high in phosphoric acid, and a general mixture high in nitrogen, the latter being employed for the later manuring operation in the pruning cycle. Beyond this it is impossible to generalize, so great is the variety of formulae. Typical Ceylon mixtures are as follows:

Pruning Mixture		lb.
Fish guano	...	220
Bloodmeal	...	70
Nitrate of potash	...	80
Rock phosphate	...	80
Concentrated superphosphate		50
		500

Equivalent to: N 31·0 lb. per acre; P_2O_5 59·40 ,, ,, ,,; K_2O 26·40 ,, ,, ,,

General Mixture		lb.
Groundnut cake	...	200
Fish guano	...	200
Bloodmeal	...	100
Sulphate of ammonia	...	100
Muriate of potash	...	50
Superphosphate	...	100
		750

Equivalent to: N 60·5 lb. per acre; P_2O_5 34·0 ,, ,, ,,; K_2O 25·0 ,, ,, ,,

The most striking feature of such mixtures is the variety of nitrogenous manures they contain. The usual explanation for this is that under conditions of high rainfall it is necessary to arrange for successive relays of available nitrogen, although work on nitrification of organic artificials lends no support to the view that maximum nitrification is long delayed. Nor does this theory take any account of the real complexity of the carbon-nitrogen cycle in the soil.

In Java the concept is much simplified by the use of inorganic nitrogen; the manure applied at pruning time contains nitrogen and phosphoric acid, whilst that applied on other occasions consists solely

of nitrogen. In India Carpenter [6] recommends a formula for a four-year rotation in manuring as follows:

Year	N	P_2O_5	K_2O
1st	30	...	30
2nd	30	20	20
3rd	30	...	20
4th	30	20	20

The question whether it is necessary or desirable to alter the ratio of the various constituents at different stages in the pruning cycle still needs direct experimental investigation. There is a general impression that potash manuring gives negligible responses, and phosphoric acid is mentioned doubtfully by the Indian and Java workers. Nitrogen alone gives a striking performance. Allowing for a large degree of individuality, 30 to 40 pounds of nitrogen per annum is a fair average application [10]. It is interesting to relate these manurial dressings to the quantities removed by the crop. For a 500-pound yield the figures are of the order N 20 lb.; P_2O_5 4 lb. K_2O 8 lb per annum [11]. Reliable data for the quantities removed in prunings are not available.

EXPERIMENTAL EVIDENCE

Reliable experimental evidence in support of the practices and opinions outlined above is by no means extensive. A green leaf crop plucked continuously at intervals of a few days, often under adverse weather conditions, presents numerous difficulties when accuracy and comparability are aimed at. Until recently no regard was paid to the technique of tea experiments, and formerly experiments were either confined to single plots or, if replicated, were interpreted without any knowledge of the errors involved [12].

The experiments chosen as illustrations in this section are confined to the more recent replicated type and are drawn from the records of the experiment stations of North India, Java, and Ceylon. The Indian experiments have dealt mainly with the nitrogen question; Java results cover a wider range; whilst in Ceylon, where specialized

research on tea is of recent origin, potash and nitrogen have so far received attention The data from the various stations are given in Tables 1-5.

Nitrogen.—A series of six years' results of nitrogenous manuring are available from the North India Station [13].

TABLE I.

Effect of 30 lb. Nitrogen on Yield in lb. of Tea per acre (India)

Sulphate of ammonia 150 lb.; Superphosphate 150 lb.; Muriate of potash 60 lb.

Year		Nitrogen and Minerals	Minerals only	Increase due to N
1922	...	648	640	8
1923	...	768	688	80
1924	...	736	592	144
1925	...	824	600	224
1926	...	744	544	200
1927	...	704	464	240

Allowing for seasonal fluctuations, a progressive decline in the plots deficient in nitrogen is evident, and over the whole period the effect of nitrogenous manuring amounts to an average of 25 per cent. increase in yield. Short-time results in Ceylon [14] and Java [15] show smaller but substantial increments of a confirmatory nature (Tables 3 and 4). There is no doubt about the response of tea to nitrogen.

In view of the different policies adopted in the use of organic and inorganic manures, the results of trials of different forms of nitrogen are of special interest [10, 16]. Seven years' results in India give the following percentage yield-increases over plots receiving no nitrogen. Side by side are results of a more highly replicated experiment of a single year's duration.

TABLE II.

Percentage Yield Increases for various Nitrogenous Manures (India)

		Seven-Year Average	Single Year
Nitrate of Soda	...	22·3	25·0
Sulphate of ammonia	...	19·2	25·6
Ammonium chloride	...	—	25·0
Oilcake	...	16·8	23·9
Bloodmeal	...	—	18·7
Cyanamide	...	—	23·0
Green manure	...	27·6	—
Sinews	...	9·9	—

Of the results from the long-term experiment, it is probable that only sinews show a real difference, since this experiment was confined to threefold replication. The single year's results show a striking uniformity except for bloodmeal. A substantial decrease is claimed for the latter, but in the absence of the relevant error figures it is doubtful whether a real difference can be claimed. This result from a sevenfold replicated experiment may be judged in the light of the significant differences established in the Ceylon experiment where replication was twelvefold.

The Ceylon experiment [14], for which two years' data are available, gives no indication of any superiority in yield from 'organic' nitrogen. Further results of high accuracy must be accumulated before an incontrovertible judgment on this question is possible.

TABLE III.

Effect of Nitrogen and Potash on Yield of Tea (Ceylon)

Yield in lb. dry matter per acre.

	Nitrogen quantities*			Nitrogen type			Potash quantities †		
	Nil	20 lb.	40 lb.	Blood-meal	Cyana-mide	Sulphate ammonia	Nil	20 lb.	40 lb.
Yield per acre	502	516	527	523	518	523	518	509	517
Yield per cent. of mean	97·5	100·2	102·3	100·3	99·4	100·3	100·5	99·0	100·5
Significant difference per cent.		5·5			6·7			5·5	
Yield per acre	878	942	1,025	990	967	994	952	932	961
Yield per cent. of mean	92·6	99·4	108·0	100·7	98·3	101·0	100·4	98·3	101·3
Significant difference per cent.		5·2			6·3			5·2	

* In presence of 30 lb. K O and 30 lb. P_2O_5.
† In presence of 30 lb. N and 30 lb. P_2O_5

TABLE IV.

Effect of Nitrogen, Phosphate, and Potash (Java)

(Average of three experiments with sixfold replication)

Percentage increase due to	Nitrogen alone ...	9·3
	P_2O_5 in presence of N ...	1·3
	K_2O in present of N and P_2O_5 ...	0·55

Potash.—The most detailed evidence comes from Ceylon and Java [14, 15]. Neither station shows a return for potash manuring. The Java experiments were not extended beyond a fourteen-month period; in Ceylon the results are in their third year. It is at present impossible to say whether this unresponsiveness is due to adequate natural reserves or whether it is the aftermath of more than adequate manuring in the past. The soil types of Java and Ceylon are markedly different, the former being volcanic, and the latter mainly gneissic. The experimental evidence so far confirms current tradition.

Phosphoric acid.—Replicated trials on the phosphatic problem are confined to Java [15]. They indicate a very dubious response to this type of manure.

Lime.—Tea is probably the most important crop that definitely prefers an acid soil reaction. Liming is seldom resorted to even to stimulate green manures, though at one time small doses were recommended as preventative of root-disease. Instances of healthy growth at a pH as low as 4·5 are frequent. Prillwitz regards this as a suitable reaction for young plants [17]. Gadd [18] obtained a maximal growth in the region 5·3 to 6·5. Above this limit, definite pathological symptoms set in; root-growth ceases, and the stem becomes stunted and makes abortive attempts to produce new leaves.

Time of application.—In Ceylon and Java, where the tea bears continually except for a short period of recovery from pruning, applications of manure are either annual or at periods of months arranged to fit in with the pruning cycle. In North India, where a winter period of unproductiveness is experienced, the question arises as to how soon or late in the growing-season manures can profitably be

applied. Cooper and Harrison [20] applied manures at five different times between February 15 and July 27, and their results indicate that the yield increments decrease if manuring is unduly delayed.

TABLE V.

Increases due to Manuring at Different Dates (India)

(Sulphate of ammonia 200 lb. ; Superphosphate 140 lb. ; Sulphate of potash 60 lb. per acre)

Time applied		Increase lb. per acre
February 15	...	215
March 27	...	207
May 6	...	193
June 17	...	220
July 27	...	153

In Ceylon and Java the problem of time of manuring takes on a rather different aspect, namely that of its relation to the time of pruning. Two schools of thought are prevalent, one recommending manuring immediately after pruning in readiness for use by the recovering plant, the other favouring manuring some time after, when a recovery is more pronounced. The latter school contends that recovery is conditioned mainly by the status of the plant's food reserves and can be but little helped by manuring. The failure of the Ceylon experiment to show any significant response to manuring at pruning time (Table 3) must act as a stimulant for further work on recovery from pruning in relation to the plant's capacity to make effective use of available supplies.

Frequency of application.—Cooper's results [20] with single and divided doses applied at approximately three months' interval show that the effect on total yield is negligible, but that differences in yield-distribution during the season are marked.

THE EFFECT OF MANURING ON QUALITY

The manuring of tea would be a relatively simple matter if yield were the only consideration. Experience with other crops has shown that it is when quality is an important and variable characteristic that

the culture of a crop becomes enhanced in difficulty. Tea is pre-eminently a crop where quality has prime consideration and the crux of the matter is that a quantitative measure of quality is lacking. Sugarcane, cinchona, and such-like plants have a definite chemical constituent by which to measure quality; fibre crops have physical properties that can be tested; but tea has both, though what their ultimate units are is very incompletely known. Common experience has, however, shown that quality in tea, no matter of what constituents it is compounded, is conditioned by the nature of the leaf, which is the raw material. In this connexion two points of importance stand out: (1) climatic changes play a large part in determining quality, and (2) the first harvests of 'flush' after recovery from pruning always produce inferior teas. A frankly empiric consideration of observational data on these two points has led to the view that rank growth is deleterious to quality and that slow growth, except when it is accompanied by wet sunless weather, gives a high-class product. The object of the practical cultivator and experimenter alike is to produce quality without sacrificing yield unduly, and *vice versa*.

On the chemical side of the quality question some progress has been made, but it is of very restricted application. A knowledge of the water-soluble extract and its tannin-content furnishes some indication of quality for teas grown under a uniform system of cultivation and climate such as obtains on a particular estate [21], but as soon as one crosses the border-line on to even a neighbouring plantation the correlation breaks down. In any case the chemical composition of tea expressed in such simple terms as those considered gives as yet far too incomplete a picture of quality. Consequently the only method of judging the results of manuring on quality at present lies in the valuation of the finished article. The difficulties inherent in this procedure are formidable in the extreme, for besides the necessity for carefully controlled field experimentation, equally well-controlled manufacture is called for. When, ultimately, either chemical or other criteria are put to the test, it can only be in comparison with the subjective technique of the tea-taster. Under these circumstances

it is not surprising that little progress can be reported on the subject of manuring of tea and its effect on quality.

The Ceylon Tea Research Institute alone amongst its kind possesses a factory equipped for experimental manufacture of tea, and a first attempt to study manuring in relation to quality is in progress there. The produce of the experimental plots which provided the yield data of Table 3 is systematically manufactured plucking by plucking on similar batteries of small-scale machinery which allow of simultaneous manufacture of the produce from the various treatments.

The two experiments so far attempted are concerned with the question of nitrogenous manuring:

(*a*) The effect of 40 lb. of nitrogen per acre compared with 'no nitrogen'.

(*b*) The effect of equivalent dressings of nitrogen in three forms, bloodmeal, cyanamide, sulphate of ammonia.

Evans [22] has published the results of the first year's manufacture involving the quantity comparison (*a*). Since the use of a permanent standard is impossible in so perishable a product as tea, one treatment is taken as standard with an arbitrary marking of ten, and the other is assessed by comparison. Table 6 gives the total score reached for the two treatments considered under five heads.

TABLE VI.

Comparison between Teas receiving No Nitrogen and Teas receiving 40 lb. Nitrogen per acre.

	No Nitrogen	40 lb. Nitrogen per acre
Colour ...	332·0	309·5
Strength ...	367·0	366·5
Pungency ...	402·0	385·6
Quality ...	438·0	427·7
Flavour ...	346·0	362·2

The differences evident between the markings are very slight, the largest being only 7·3 per cent. for colour in favour of 'no nitrogen'. Statistical analysis has shown that this difference is not great enough for significance. For the comparison of the various kinds of nitrogen a full year's data are not yet available.*

PROBLEMS REQUIRING INVESTIGATION

The foregoing data show that the knowledge of the principles of tea manuring is very incomplete and still very empiric. There is need for considerable expansion in field experimental work, and the recent advances in both the theory and practice of field experimentation, by removing to a large extent technical difficulties, render the future auspicious for this expansion. The most fruitful line of advance would seem to lie along the lines of moderately complex experiments of a semi-permanent nature. Much of the work already undertaken is of too short a duration to solve the problems associated with a long-term perennial crop for which the natural cropping period is a pruning cycle that extends in some cases to four or more years. In the absence of a continuous and *uniform* programme, cumulative effects and progressive deficiencies of considerable importance are virtually unresolvable.

The aspects discussed in this paper all need further investigation, particularly those relating to quality. In addition, there are others which are at present untouched. The interaction of manurial factors amongst themselves is unexplored territory, as is also the interaction of manuring with the various types of pruning. The latter is of special interest because the tea cultivator is concerned not only with total crop but with yield-distribution during the pruning cycle.

Green manuring of tea has raised the question of the effect of one crop upon another. The results of work on temperate annual crops

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* Later data will be found in a further paper by Mr. Eden in this number.—*Ed.*

are only of very general application. The solution to the problem of soil erosion awaits an authoritative dictum on the matter of the effect and management of cover crops.

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THE PRUNING OF TEA*

F. R. TUBBS.

This is the first time that I have had the opportunity of discussing with you some of the more general principles applicable to pruning tea in Ceylon. Let me commence with a note of warning. Firstly, the results of the St. Coombs experiments at present only cover a period of two years from pruning — the last records only becoming available during last week. The experiments are being continued, but until the cycles are complete we must be cautious in assuming that the results which show up in the first two years will be representative of the results which will be available when the whole cycle of four years is completed. Secondly, I would draw your attention to a principle that will emerge from the results I shall describe — namely that if any generalisation can yet be drawn from my experiments, it is that there is no one ideal method of pruning — the jât of bush, the elevation of the estate, the season of the year all appear to demand their modifications in the pruning method. The final word cannot be spoken as yet and this talk must be regarded as being in the nature of an interim report.

The principal pruning experiments of the Tea Research Institute have been designed to test three types of pruning, namely clean pruning, rim-lung pruning, and cut-across, under diverse conditions. At St. Coombs, at an elevation of 4,600 feet, the three methods were each used at three times of the year, such that recovery from pruning took place during the north-east monsoon, the so-called "dry weather", and the south-west monsoon, respectively. By this means we can obtain information as to the value of a particular method at 4,600 feet, as to the effect of the season of pruning, and as to whether the value of a particular method alters relatively to the others at different seasons of the year. This, however, does not

* Lecture given before the Dimbula District Planters' Association on May 21st, 1934.

supply us with any information as to what may be expected to occur at different elevations and, for this reason, two experiments homologous with the April portion of the St. Coombs experiments were laid down, one was at Peradeniya at an elevation of 1,500 feet, and one at Galatura at an elevation of 200 feet above sea level. From the results of these it will be possible to judge whether different methods of pruning are advisable at different elevations.

Dealing first with the rate of production of shoots above the tipping level during the pre-tipping period it was found that the season of pruning during 1931-32 had no significant effect. The method of pruning employed, however, was found to have a considerable effect, cut-across pruning resulting in a far quicker production of new shoots than did rim-lung or clean pruning. This is due to the fact that the buds on the younger branches which remain after cutting across burst into growth far more rapidly than do those situated on the older and thicker frame branches. The analysis of the records indicates that there was a distinct tendency for the effect of a given type of pruning to vary when performed at different times of the year.

Considerable differences in the effects of the methods of pruning used upon the rate of recovery were found according to the elevation of the tea under experiment. At 4,600 feet, on St. Coombs Estate, the results from April pruning plots indicated that the recovery of rim-lung pruned bushes was the slowest, followed by clean-pruned bushes which, in turn, were slower than cut-across bushes. At 1,500 feet, at Peradeniya, the rim-lung and clean-pruned bushes did not differ significantly in their recovery rate, both being slower than the cut-across bushes. At 200 feet, at Kiriella, the rim-lung recovered quicker than the clean-prune or the cut-across.

In short, the rate of recovery at 4,600 feet was not affected by the season of pruning, but cut-across pruning gave a quicker return. The lower the elevation, however, the quicker was the recovery shown by the rim-lung pruned plots.

In my Conference paper of 1933, I emphasised that to associate these results with prophecies about yield would be merely making shots in the dark. Now, however, yield records are available for examination in connection with them. The records have been collected on a bush basis, but for ease of comparison I have converted them into an acreage basis at 3,000 bushes to the acre. Taking first the effect of the season of pruning at St. Coombs, the results are shewn in Table I.

TABLE I.

Time of Pruning	Dry weight yield per acre of flush
1st-4th September, 1931.	1585
5th-7th January, 1932.	1384
10th-13th May, 1932.	1384

We find that statistical analysis of the results indicates that pruning in early May does not result in any different result to pruning in early January. Pruning in early September resulted in a significantly higher yield than pruning at the other two seasons. The difference in yield is considerable, amounting to almost exactly 200 pounds in the two years.

When we commence investigating the effect of season on yield the difficulty due to the variability of the character of the seasons from year to year immediately crops up. For example, since the Tea Research Institute Laboratories have been in Dimbula apparently no year has been climatically "normal" in the opinion of those old established members of the district who are qualified to judge! The plots at St. Coombs were pruned at three seasons during the year 1931-32 and our accurate knowledge of the effect of different seasons on reaction to pruning is confined to the results of that experiment.

In so far as one season is never exactly duplicated by another, we cannot expect that the results will be exactly the same when the experiment is repeated in 1935. But I think we may take it that these results give a fairly definite indication that pruning in early September leads to higher yields during the first two years than does pruning in early January or May. Moreover, it is possible to suggest

an explanation of how this comes about. In general, the major cropping period in the Dimbula district is late March, April, May and early June. A bush pruned about the end of August is in plucking by about the succeeding January. By April it has developed a large number of flushing points and is in a condition to respond to the more favourable growing weather experienced during the "rush" months. In consequence, in a cycle of two years, it experiences two periods in which climatic conditions favour rapid growth and it is in a position to respond on both occasions. This does not occur in the case of tea pruned about the end of December or April. The former does not come into regular plucking until after the succeeding "rush" period. As a result, in a cycle of two years it is only able to take advantage of one of the rush periods. Similarly, tea pruned at the end of April, while it has developed a good plucking surface by the succeeding April, is, on a two-year cycle, due for pruning before the completion of its second "rush" period. Other factors probably contribute to the observed superiority of the tea pruned in the beginning of September. For example, tipping was completed on it rather earlier after pruning than was the case with the other two series. The number of complete plucking rounds in the two-year cycle was:

August	...	64
December	...	62
April	...	63

Until data gathered from a succession of experiments such as these are available I do not think we shall be able to deal completely with the problem.

The data upon the effects of different methods of pruning on a two-year cycle yield at St. Coombs are given in Table II.

TABLE II.

Type of pruning	Dry weight yield per acre of flush
Clean Pruning	1478
Rim-Lung Pruning	1427
Cut-Across Pruning	1448

These figures are based upon pruning at all the three seasons, and indicate that, for two-year cycles, the method of pruning used at this elevation will not, on the whole affect the cycle yield, since no importance can be attached to the small differences observed. Nevertheless, when we consider the question of interaction between the method of pruning and the season in which it is applied it is found that statistical analysis of the results indicates a significant tendency for the relative value of a given mode of pruning to vary at different seasons. Table III showing the yields per acre from the three pruning treatments at the three different seasons will illustrate this.

TABLE III.

Pruned	Clean	Rim-Lung	Cut-Across
1st-4th September, 1931.	1586	1515	1653
5th-7th January, 1932.	1371	1411	1369
10th-13th May, 1932.	1477	1354	1321

In the September plots the best results were given by cut-across pruning, in the January plots by rim-lung pruning and in the May plots by clean pruning. These, we must remember, are results obtained from pruning at different times during 1931-32 only. I do not feel that they can be adequately discussed until we have repeated the experiments. This, I would emphasise, is not due to any lack of trust of the figures, but is due to the fact that if we are to derive any general rule concerning anything so variable as seasonal effects, we need results derived from pruning at different seasons in a number of years.

Up to the present, we have been considering the results obtained at St. Coombs, which may be taken as typical of those estates at higher elevations which receive rainfall during both monsoons. But in any survey of pruning methods, the factor of elevation must be taken into consideration. As I have already explained, the three methods of pruning tested at St. Coombs were also tested at Peradeniya and Kiriella at elevations of 1,500 feet and 200 feet respectively above sea level, the pruning being done at the end of April 1932, in each case. An examination of the yields (Table IV)

shows that the three methods by no means maintain the same order of merit at different elevations.

TABLE IV.

Elevation	Dry weight yield per acre				
	Clean		Rim-Lung		Cut Across
4,600 feet	1477	>	1354	=	1321
1,500 ,,	1958	=	2011	=	1887
200 ,,	1869		2098	<	2203

At 4,600 feet clean pruning at the end of April has given better results than rim-lung or cut-across pruning. At Peradeniya at 1,500 feet this difference can no longer be detected, there being no significant difference between the yields under the three treatments. When we consider the Kiriella results, obtained from plots at an elevation of about 200 feet above sea level, clean pruning is found to be definitely inferior to both rim-lung and cut-across pruning. To sum up these results, we may say that the lower the elevation the poorer are the results of clean pruning and the better the results of rim-lung and cut-across pruning.

Investigations in the field and in the laboratory have provided us with some explanation of this. I do not propose to go into the whole story this afternoon, but one point merits mention. Those of you who have followed the work the Institute has been doing on the problems particularly associated with Low-Country pruning will have noticed the stress that has been laid on the fact that at the lower elevations the tea bush is often deficient in those reserves of organic foodstuffs in its roots which are essential if it is to recover from such a drastic operation as pruning. As a result, either whole bushes or large portions of the frame die back, causing much damage subsequently to both the health of the bush and to its productiveness. Field observations had led to the view that the higher the elevation the higher the amount of reserve substances stored in the tea roots and it was thought desirable to examine the question more fully. By the courtesy of a number of Superintendents, samples of tea roots from fields in which approximately eighteen months had elapsed

from pruning were obtained from all over the tea districts. The total carbohydrates removed from the dried and ground roots by a standard form of acid extraction was taken as a measure of those reserves. When the percentage of carbohydrates present was plotted against the elevation of the field, it was found that the points tended to fall on a straight line, tea roots at sea level being computed to contain on the average about 10 per cent. roots from tea at 7,000 feet containing about 26 per cent. Since the leaf is the mechanism whereby the plant is enabled to manufacture the substances required to produce new shoots and leaves after pruning, it follows that the lower the elevation the more essential it is that a sufficient number of leaves remain on the pruned plant to supply these substances.

On fields situated at elevations below 1,500 feet it is essential that this matter be dealt with and I should deprecate any clean pruning below this level. Occasional cases arise of carbohydrate deficiency at higher elevations and I would suggest that even up to 3,000 feet some provision be made for leaving lungs or fringe branches on fields in which dieback occurs. I do not suggest that the forms of dieback met with at elevations above 1,500 feet are by any means regularly due to a carbohydrate deficiency — in fact, cases have been met with where this is known not to be a contributing factor.

The mention of fringe branches brings me back to higher elevations once more, for I wish to put the possibility to you that, in the district as a whole, it is not necessary to reduce the diameter of the bushes as much as is normally done when pruning. The diameter of the pruned surface of a bush depends on both the method of pruning and upon the height above the ground at which it is pruned. From figures obtained at St. Coombs, it appears that, if the bush frames are taken as circular, and if an acre is considered to contain 3,000 bushes, only 39·5 per cent. of the ground is covered by the frames of clean-pruned bushes, compared to 66·3 per cent. covered by cut-across bushes. This is due to the fact that the cooly has been accustomed to remove all new low-lying shoots from the bases of the bushes when clean pruning. Two photographs that I have here

A.

B.

illustrate the point. The bush was photographed when pruned in such a way as to leave all the side branches (A) and again after it had been "cleaned up" by a pruner (B). The tremendous reduction in diameter that resulted is obvious. It is unlikely that the fringe branches would have yielded much in the next cycle, but they would have been thickening up and developing into useful portions of the frame. What is the use of my instructing a plucker not to pluck the side branches below the plucking surface if I cut them all off when I prune the bush ? A large bush undoubtedly yields more than a small one and since planting distances have been fixed in the past, it will pay to make the bushes cover the area they have been allotted as efficiently as possible. I do not think the fact that a good cover is often obtained three years from pruning is sufficient. The ideal is to obtain as large a proportion of that cover as possible as soon as the bush comes back into tipping, and that can only be achieved if the spread of the pruned frame is never unnecessarily reduced.

A REVIEW OF THE FIRST PRUNING CYCLE OF THE TEA RESEARCH INSTITUTE MANURIAL TRIALS.*

T. EDEN.

I have previously addressed your Association on two general topics, the physical properties of the soil, and the part played by green manuring in soil and plant economy. Today I propose to particularise and to deal with the manurial experiments at St. Coombs which have recently completed a pruning cycle. I believe it is opportune to choose this topic, because not only does the pruning cycle provide the natural time unit for reviewing any experimental aspect of tea culture, but the present time marks the beginning of what will probably be a return to a more liberal policy in manuring than has been prevalent during the last two years.

A year ago at the Institute's Conference I described the results obtained in the first two years of the existing experiment, and the final year's data have since been published in the report for 1933. I shall take this opportunity of refreshing your memories of the trend of these past results before passing on to discuss the new material.

The summarised yields for the period are given in Table I (a), (b) and (c). In explanation it should be said that in considering yields from incremental doses of nitrogen no account has been taken of the potash level, which was not uniform on all plots: that is to say that for any given level of nitrogen there were plots receiving some nil, some 20 and some 40 pounds per acre of potash, but the different nitrogen levels were all comparable in this respect. Similarly with respect to potash increments there were different nitrogen levels which were equally balanced up. The situation should be quite clear if I state that yields in Table I (a) are produced by the stated doses of manure in the presence of an average dressing of 20 pounds

* A lecture delivered to the Dolosbage-Kotmale Planters' Association on May 25th, 1934.

per acre of potash, and in Table I (b) the average nitrogen dose was also 20 pounds per acre, 30 pounds of phosphoric acid per acre was common to the whole experiment. In a similar manner the comparison of types of nitrogenous manure are made on the basis of 20 pounds per acre of nitrogen and potash, and 30 pounds per acre of phosphoric acid.

TABLE I

Effect of Incremental Doses of Nitrogen and Potash and of Various Types of Nitrogen on Yield of Tea.

(a) Nitrogen

	Nil	20 lb. p. a.	40 lb. p. a.
1st year ...	502	516	527
2nd ,, ...	878	942	1,025
3rd ,, ...	582	672	742
Average ...	654	710	765
Incremental difference		56	55

(b) Potash

	Nil	20 lb. p. a.	40 lb. p. a.
1st year ...	518	509	517
2nd ,, ...	952	932	961
3rd ,, ...	672	653	670
Average ...	714	698	716

(c) Kinds of Nitrogen

	Blood Meal	Cyanamide	Sulphate of Ammonia
1st year ...	523	518	523
2nd ,, ...	990	967	994
3rd ,, ...	701	688	732
Average ...	738	724	750

Points of interest in these figures are as follows:—

The middle year of the cycle gives the greatest yield. The first year included the recovery from pruning and there were only 25 plucking rounds, but the other years stand on a par in this respect having 40 rounds each. A rather different type of experiment would

be necessary to determine whether the drop in yield in the third year is due predominantly to weather conditions or to an ageing effect as time from pruning increases, but it is interesting to note that the gross effect of the nitrogenous dressing was as marked in the year of lower yield as in the foregoing season, and that therefore it was proportionately greater in that final year.

Secondly, the effect of the nitrogen has been strictly proportional to the dose. Over the whole cycle twenty pounds of nitrogen has given a return of 56 pounds of dry weight leaf per annum (approximately equivalent to made tea) as against 55 pounds for the additional twenty pounds of nitrogen. Actually in favourable conditions the return is higher because the first year gave no certain return at all. There are differences apparent in the first year but, in the light of the experimental errors that have been calculated for every stage of this experiment, we cannot be sure that such small differences are not due to the element of chance which cannot be entirely eliminated. If we confine our attention to the two years in which nitrogen gave a benefit the average gain for both increments of twenty pounds of nitrogen is 77 pounds of tea. I have previously dealt with the question of the lack of response in the first year and have shown how the interpretation of the results is complicated by the fact that the growth up to the tipping period showed a small but definite benefit from nitrogenous manuring. The failure of the manured plots to maintain their superiority is an interesting point on which more results must be brought to bear before a decision as to the merits of a pruning mixture can be arrived at.

Not only do these results show that the law of diminishing returns (*i.e.*, that higher doses tend to give progressively smaller returns) has not operated over the range of the manurial quantities studied, but they afford evidence that a manurial ratio that is economic in one year of the cycle is equally efficacious in another. It is a common practice in Ceylon to have widely differing manurial ratios in the three years of a pruning cycle; the necessity for this receives no support from these data as regards potash and nitrogen.

Potash has been uniformly unproductive throughout the period, such differences as show up being smaller than those for which certainty can be claimed. The same applies to the three different types of nitrogen, which show statistically an equivalent level of performance. In this connection I would draw your attention to the accompanying diagram* from which it is apparent that not only are the average yields over the period the same, but also that the distribution of yields for the three sources of nitrogen during the period are closely approximate. This has its bearing on the quality question, for if at any time in the cycle the yields from one kind of nitrogen had forged ahead of the others, our biochemical investigations show that a time might come when this rankness of growth caused loss of quality. It did not occur, as we have seen, even with differing doses of nitrogen, and in the figures for kind of nitrogen it is evident that there is not even the predisposing cause. I shall deal with the general question of quality later.

The flush taken for manufacture has a definite relationship to the rest of the bush and the nutritional aspect of foliage leaf and wood production is naturally of importance. There is not only the question of the healthy development of the frame but the assessment of what are the relative losses and gains in elaborated nutrients when bushes are pruned and the leaf material returned to the ground.

Bearing in mind such aspects, an estimate of pruning weights has been made on the St. Coombs experiment. It is obvious that the weighing on a comparable basis of some $4\frac{1}{2}$ acres of pruning in different states of dryness would be impossible, so that a random sample from each plot had to suffice. Actually 25 bushes per plot were taken and the prunings conveyed to the factory where they were dried by conditioned air in an unoccupied withering loft. After a month of this treatment the dried foliage leaves were separated from the branches and the leaf and wood for each plot separately weighed and recorded. In discussing effects of nitrogen and potash

* Not reproduced here.

manuring each level of each nutrient was accordingly based on 450 bushes (the product of the sample and replication number). Assuming a stand of 3,000 bushes per acre the following are the dry weights in pounds per acre.

TABLE II.

Pounds per acre of leaf and wood removed in pruning.

	Nitrogen			Potash		
	Nil	20 lb. p. a.	40 lb. p. a.	Nil	20 lb. p. a.	40 lb. p. a.
Leaf	**1547**	**1560**	**1761**	1549	1668	1651
Wood	**2052**	**2177**	**2514**	2161	2284	2298

The errors inherent in this portion of the experiment are of course greater than in the flush data since the number of bushes employed is small. We are in fact not at present in a position to talk with confidence about differences in yield of less than 11·3 per cent. in the case of leaf and 15·5 per cent. in the case of wood though in a further examination of the data as opportunity occurs I hope to be able to reduce the margin of error.

At present the leaf data show a maximum effect for nitrogen of 13·3 per cent. and for potash 7·4 per cent.; for wood the range is 20·5 and 6 per cent. respectively. Hence the response of wood and leaf has been placed beyond doubt in the case of nitrogenous manuring but not for potash. This follows the findings for flush, and as far as it goes indicates that there is no selective response of one part of the bush to a particular nutrient. The bush is an organism and not an assembly of mechanical parts and what conduces to growth and vigour in one part has its reflection in a similar response in other spheres. I cannot therefore give a magical manurial formula for a mixture which will during a restriction period curtail the crop by the required 12½ per cent. and utilise the balance of the manure for increasing wood growth, a request that has cropped up in correspondence regularly during the restriction period.

A balance sheet of nutrients added to and removed from the ground over a pruning cycle would be of considerable interest but the construction of such a document presents formidable difficulties. To weigh and sample roots for analysis would involve the removal of large numbers of bushes to achieve even the same level of accuracy as is shown by the pruning results. We can, however, draw up the balance sheet as far as we have gone and, bearing in mind the limitations of the method, draw tentative conclusions. The analyses of the samples are still in progress, but by way of illustration we may take nitrogen, the most important manurial constituent.

Table III shows the amounts of nitrogen per acre removed by the specified parts of the crop in three years.

TABLE III.

Pounds nitrogen removed per acre.

	Receiving no Nitrogen		Receiving 120-lb. Nitrogen	
Flush ...	78·50	88·75	91·75	104·25
Wood ...	10·25		12·50	
Foliage ...	30·95		35·20	
	119·70		139·45	

First let us consider the tea which has received no nitrogen. The whole of the flush leaf and wood considered has grown during the pruning cycle, and although there has necessarily been a certain withdrawal from reserves left in the other parts of the bush previous to this pruning cycle, the major portion of the nitrogen has come from the soil. No less than 120 pounds odd is accounted for in the three years growth cycle, of which 89 pounds is permanently removed. Turning to the plots that have received 120 pounds of nitrogen in all, the total figure is close on 140 lb. of which 104 are permanently removed. The difference between the manured and unmanured plots is only 20 pounds of nitrogen per acre which is all we have to show for 120 pounds added. There is the main stem and root to be considered, and it is possible that some of the extra nitrogen added could be traced in a similar fashion to those portions.

It is unlikely that in this way more than a fraction of the balance can be accounted for and it seems probable that the recovery of the added nitrogen is relatively inefficient. I do not wish to press these figures beyond the limits of their experimental accuracy but they emphasize two points; (1) that soil and not manure is the backbone of tea nutrition; and (2) that if recovery of added manure is as poor as these results imply, every effort must be made to conserve the unexpended portion, if such there be. The cause of this possible low efficiency cannot in the light of the results from different kinds of nitrogen be attributed to loss of soluble artificials as distinguished from organic artificials; they are both in the same category: a mere substitution of the latter for the former cannot be expected to help matters. If any of the unrecovered nitrogen is to be immobilised in the soil, it must be by the agency of green manuring. These results indirectly warn us that the only thoroughly efficient manner in which to grow tea is by stopping soil erosion and delaying as much as possible the degradation of the organic matter in our soils.

QUALITY EFFECTS.

No matter how desirable a scheme of manuring may be in promoting good and healthy growth, if by adopting it quality of the finished tea is impaired its value is minimised. There remains the consideration of the effects of the manurial programme on quality in our experiments.

So far, as you are aware, we have considered only the nitrogen factor and have manufactured the leaf from the experimental plots plucking by plucking, so that two comparisons can be made between

(a) No nitrogen and 40 lb. per acre.

(b) Bloodmeal and either sulphate of Ammonia or Cyanamide.

I should mention that this part of the work was initiated by Dr. Evans, and that more than half of the data on which I am drawing was collected during his connection with the Institute.

During the pruning year we relied solely on broker's valuations. During the second and third years an additional refinement was introduced, namely the assignation of marks to teas for the several qualities of colour, strength, pungency, quality and flavour which are ordinarily taken into account in a broker's valuations. The marks given centre round an arbitrary value of ten for the standard treatment in any comparison, and the other treatments are marked higher or lower as the case may be. In the case of the comparison of teas unmanured by nitrogen with those receiving 40 pounds per acre, we have accumulated fifty tests on all these characters. The average superiority or inferiority of the no nitrogen teas over this period on the aforementioned marking basis is as follows:—

Colour	Strength	Pungency	Quality	Flavour
+0·48	+0·26	−0·10	+0·72	−0·06

In no instance has the use of nitrogen, in the quantities recorded, caused an average deterioration amounting to a single unit of marking on a datum line of 10; and there are no obvious periods when either the one or the other gains a marked superiority. None of these differences between the two treatments can be regarded as either statistically significant or technically important. The dead level of performance of the two treatments is further reflected in the study of the composition of made tea. Such differences as exist between the figures for percentage composition in Table IV. are within the Experimental error.

TABLE IV.

Comparison between differently manured teas. Mean composition in yearly periods.

	1931	1932	1933
Treatment		Extract per cent.	
No. nitrogen	40·0	41·3	43·3
N. at 40 lb. p. a.	40·2	41·1	43·4
		Nitrogen in extract per cent.	
No. nitrogen	1·60	1·65	1·57
N. at 40 lb. p. a.	1·60	1·71	1·64

Treatment	1931	1932	1933
		Tannin Equivalents	
No Nitrogen	215·6	230·8	258·2
N. at 40 lb. p. a.	215·3	228·8	255·4
		Caffeine per cent.	
No. nitrogen	3·23	3·19	2·96
N. at 40 lb. p. a.	3·26	3·30	3·13
		Ash per cent.	
No nitrogen	5·07	5·34	5·27
N. at 40 lb. p. a.	5·02	5·23	5·18

Whilst no reliable differences exist between manurial treatments there is a probable increase in extract as the pruning cycle advances, and a definitely significant increase in tannin. These differences will provide material for further thought and investigation in connection with the recent advocacy of longer pruning cycles.

INORGANIC & ORGANIC NITROGEN

The investigation of differences between teas manured with different types of nitrogen has been prosecuted over the last twelve months in an exactly similar fashion. In this case the results from different brokers marking the same tea merit attention.

TABLE V.

Marking differences (Blood Meal—Sulphate of Ammonia) in Teas.

	Colour	Strength	Pungency	Quality	Flavour
Broker A.	0·81	0·81	0·19	0·06	0·31
Broker B.	0·37	0·05	0·00	0·32	0·32
Broker C.	0·75	**3·75**	**2·88**	**4·36**	0·21

The first two brokers agree in giving marks that show no significant difference between organic manures, represented by bloodmeal, and inorganic manure, such as sulphate of ammonia. Broker C on the contrary has consistently found the bloodmeal better than sulphate of ammonia in the three qualities in heavy type. Inspection of the individual markings (sixteen in all) shows that he has allowed himself much greater latitude in expressing his dislikes and preferences than the other two. It must be confessed that such

violently contradictory opinions on the same sample present a formidable problem to the Institute in its attempt to standardise quality determination, and it may be that a better system of making will have to be evolved; whatever the differences that attracted the attention of Broker C were, they are not reflected in the composition of the teas as ordinarily determined.

Differences in composition of teas differently manured.

	Extract per cent.	N. in extract per cent.	Tannin Equivalent	Caffeine	Ash
Bloodmeal	44·3	1·7	262	3·3	5·3
Sulphate of Ammonia	44·2	1·6	259	3·3	5·3
Cyanamide	44·1	1·6	263	3·3	5·3

At present the situation, as we see it in the light of yield reactions, composition, and conflicting broker's valuations, is that no consistent difference worthy of general acceptance has emerged. We shall be able to test these conclusions further in the cycle that has just started.

THE CULTIVATION OF SHADE TREES, GREEN MANURES AND COVER CROPS.*

T. EDEN.

It is now upwards of thirty years since Bamber and Wright commenced their advocacy of green manuring of tea, and although in an agricultural sense this is not a long period there is no doubt that great progress has been made. My purpose today is to deal with the underlying principles of green manuring, to indicate their general application and I hope that my discourse will provide material for more detailed consideration in the light of your own locality, experience and difficulties when discussion time arrives.

I can of course lay no claim, as numbers can, to having watched the growth of green manuring over a large portion of the present century but one fundamental fact is observable even during the seven years of my Ceylon experience and that is that agriculturists are more and more inclined to regard the green manure crop as an integral part of their cultivation and not merely as a side line. To my mind this is the only progressive view, and we must henceforward agree that we are definitely growing two crops, tea and green manures, both of which require similar though not the same degree of consideration.

In what I have to say I shall assume that I can carry you with me in this view, the first implication of which is that in order to get the best return, some outlay is necessary, and a definite vote for green manure establishment cultivation *and control* is necessary. I may mention that on St. Coombs where the stand of green manure is at present much less complete than we should like, an amount up to half a cent. per pound of made tea is allocated for this purpose.

It is not a matter of indifference as to what type of green stuff one grows, that is, that of the three main types, shade, bush and low cover, no one sort can deputise for the other; each has its own specific

* A lecture delivered to the Morawak Korale Planters' Association on May 14th, 1934.

function. Tree shade, apart from its shading properties, is naturally valuable for its loppings and plays an important part in what I shall call the nutritional aspect of green manuring. As a preventative of soil erosion it leaves much to be desired. I have dealt with this on previous occasions, but the fact is so important that it may serve a useful purpose to emphasize it again. Granted that shade modifies the beating action of the rain, there remains the question as to whether the bare soil underneath can, by its own inherent percolation power, conduct away the rain sufficiently rapidly to prevent the movements of the soil particles which will inevitably occur when they become bathed in moisture. With the soil types encountered in Ceylon, considering the heavy rates of rainfall and the contour of the land, percolation is seldom if ever high enough to cope with surface run-off and one must look elsewhere for means of prevention. This is provided in part by the shallow rooting bush varieties or more ideally by a complete carpet of low cover. In planning green manure crops, therefore, there are but two alternatives, tree shade and bush crops, or tree shade and ground cover. When used in either of these combinations, the roots, the litter from leaf-fall, and the humus they provide, all help to immobilize the soil and to maintain at the optimum condition the percolation capacity of the soil surface.

If then a medium high and a low cover or bush crop are to be grown, the question of competition must be faced. With respect to air, sunlight, water and mineral nutrients some competition does undoubtedly take place, but as against this there are advantages to be set off. If, as is usually the case, leguminous species are planted, there is a positive gain in valuable nitrogen produced through the working of nodule bacteria on the roots. Moreover, tea and green manures are not exploiting identical layers of the soil so that direct competition is minimised. Air and light requirements admit of modification by careful control of the green manure. As for water supply once the green manure is efficiently established, the shade and litter it produces has an important effect on prevention of evaporation from the soil. It should be borne in mind that whereas a free soil

surface can go on evaporating moisture to a very low limit, the transpiration of a plant is regulated by mechanisms in the plant itself. On balance it has been found that even in drought conditions, well-established cover exerts a beneficial rather than a harmful effect during the period of growth.

The lopping and burial of the green stuff confers further benefits. In a short lecture these cannot be dwelt on at length, but the main effect is to return to the soil nutrients absorbed from it, and to make available for general plant growth the free gift of nitrogen fixed by bacterial means and disseminated to the green portions that are lopped. The picture that must be visualised is one of continual circulation of nutrients from the soil and air to the plant and back again. If it be asked what benefit this continual removal and restoration exerts, the answer lies in the fact that whilst the plant takes up nitrogen in a form easily lost from the soil, it returns it combined with carbon from the carbon dioxide of the air, a form which is definitely less liable to waste.

One point is of importance. Whilst not diminishing the beneficial effect of green manures, it must be borne in mind that when green stuff is grown only a portion of it is returned to the soil. Moreover, since this phenomenon of growth and return goes on continually each crop of green stuff turned in is not contributing entirely new stocks of nutrients. To make this clear, suppose two successive loppings were found by analysis to contain 40 pounds each of nitrogen, we cannot assume that we have added 80 pounds of new nitrogen in the two loppings. I mention this not to place green manuring in disrepute, but as a corrective to the view that green manuring alone can maintain a high cropping plant like tea in good heart. In nitrogen alone tea removes 5 pounds per acre for every 100 pounds harvested. It is too much to expect green manures to supply this quantity year in year out for the present cropping level desired on estates today.

Turning from this general outline to matters of detail, the first point to consider is the best way to use the green stuff obtainable

from loppings, to return, that is, as much as possible of the crop to the soil. In attempting to do this one can err on the side of cutting too frequently or too seldom. In general practice the latter is the more prevalent mistake. In an attempt to secure a large yield of loppings there is the danger of building up too large a frame of woody matter which is of absolutely no value for burying. All that is dead loss. A similar error of judgment occurs if woody material is buried. Such woody material contains valuable nutrients, but they break down in the soil only slowly and the micro-organisms that accomplish this are apt to take to robbing the soil (and thus the tea) of supplementary foodstuffs in order to finish the work. The chemist's criterion for determining whether material is suitable for burying is that it should contain at least two per cent. of nitrogen. The planters' rule to correspond with this should be to lop nothing that is not green and sappy and in the case of bush crops to do it just before flowering occurs. If, in the case of bush crops, flowering has taken place, the plant is withdrawing nitrogen from its leaves to build up seed, and the two per cent. level is not likely to be found in the loppings. This lopping process is, one admits, not one that can be done with uniform precision, and so it is an excellent practice to lop at the time of artificial manuring so that incidental deficiencies in the composition of the green stuff can be balanced by the artificial manure, whilst at the same time the major crop will not be called on to suffer. To sum up, more frequent lopping, whilst it may appear to decrease yield of loppings, is more likely to provide a better and bigger return of nutrients than the larger amount of less suitable material.

Closely linked with this question of frequency of lopping is that of the useful lifetime of tree or bush. This naturally depends on the rate of growth but here again the tendency is to leave a tree in the ground too long. Under conditions of good growth ten years is the useful life of a tree, after which replanting is advisable.

The ideal to work to is to have in any given field trees of different ages and to take them out annually so as not to denude an area

severely when removal is carried out. Such a programme has other reasons to commend it. An old tree stump is difficult to remove and if left in becomes a centre for the spread of root disease. Relatively young trees can usually be excavated entirely without undue damage to the surrounding tea.

A similar practice is beneficial with bush crops. Here the question is not one of damage to tea or the spread of root disease, but that of undoing the good work accomplished in the soil erosion prevention. It would be a great advance if contour hedges of bush manures were planted in alternate rows of different ages, so that when one row was removed, an effective barrier still remained to hold up soil wash.

I spoke earlier of regarding green manure as a crop to be cultivated and not merely as a side line; it follows that I would advocate treatment of the ground in a liberal way before establishing the crop. For trees propagated from stumps or nursery plants, holing should be as efficient as for the major crop. Nobody nowadays, one hopes, would think of putting a tea supply into a simple alavango hole. Yet with green manures the practice is only too common. Bush crops should be sown on a cultivated soil; being a small seed crop they appreciate good tilth. There is at times a prejudice against sowing bush crops in the row that has recently been manured on the grounds that the green manure will get the manure and not the tea. That view is a by-product of the 'side-line aspect' of green manuring which attempts to get something for nothing. According to the description I have given of the way the green manuring cycle works, the good of the green crops is ultimately the good of the tea. On the other hand it is seldom necessary to go to the length of a special and specific manurial application for the crop except in young clearings. At any rate the idea of a manurial mixture particularly relevant to the green crop loses a good deal of its point when it is to be shared by the major crop. For tree crops the usual estate mixture in the holes may profitably be given. The only manure of special importance for leguminous crops is phosphate which stimulates nodule formation,

and provided that the mixture used contains the reasonable proportions common in Ceylon mixtures, that will suffice. It is a mistake to manure heavily with nitrogen. Such a policy of spoonfeeding merely discourages the plant in its function of fixing atmospheric nitrogen and thus defeats one of the ends for which these crops are grown.

Before inviting you to ask questions relating to your specific circumstances, I would say a word about ground cover crops. Here a real difficulty exists because of the paucity of species that can confidently be recommended, and because many have the undesirable property of being climbers. Species, such as *Vigna* and *Calapogonium* do not flourish at our altitude, and having had no direct experience of the difficulties of control, it would be unfair for me to dogmatise on their use. Nevertheless, from the conflicting evidence that comes to hand from time to time I incline to the view that they have not had a fair trial, and in special circumstances, provided that control is persevered with, they might be of definite use, especially in young clearings where such control is possible. Much of the damage to tea soils is done in the early stages of planting when the soil is to all intents and purposes bare. I have seen Cowpea used successfully on such land at low elevations and its quick growth and easy removal make it worthy of a more extended trial. If ever a ground cover crop comes into regular use in Ceylon tea areas I hold that it should be forked in regularly and allowed to re-establish itself and not left to form a turf. Admittedly the provision and management of a leguminous cover is the toughest proposition in green manuring with which we are faced.

In the absence of a leguminous crop there is much to be said for non-leguminous weeds other than grass where, as in the case of Oxalis in Uva, an almost pure carpet of one genus is attainable, for in the long run the capital value of the soil is the main consideration and the second best is a great deal better than nothing at all. It will be well worth putting up with some inconvenience in management and possibly some initial loss of immediate cropping power if, as a result, we can put a period to the creeping paralysis of soil erosion.

INCREASING THE LENGTH OF PRUNING CYCLES.

E. G. B. De MOWBRAY.

During recent years many experiments have been made with the hope of improving that somewhat obscure but lucrative benefit known as quality. Several have taken place in the field, whilst others have dealt with work inside factories and have been confined to improved machinery or fresh ideas on manufacturing methods.

The subject embraced by these notes belongs to the former line of research, and may be described as the experiences I have been fortunate enough to obtain during the first stages of an apparently successful attempt to improve quality by judicious increases of the periods between prunings. Later experience will, I trust, bear out the initial opinions I have formed, and be of sufficient interest to make the thesis of a further essay; until then the explanations, data, and arguments as given here and in my book, are all I have to offer.

Before proceeding, it would be just as well to mention as a reminder that tea presents some of the most puzzling and obstinate problems of any form of agriculture. Unlike crops of roots and corn upon which years of experimental work can be recorded accurately and reliable averages arrived at, tea is subject to so many varying influences that the different lines of research are generally most laborious, and, unless undertaken in a cautious manner over a period of years, may easily be misleading. I write therefore as an explorer and not as one who considers that his experiences and data on this particular innovation are as yet sufficient to warrant precise opinions. Perhaps time will show that they are more than mere postulations and promote them to useful facts relating to the betterment of teas.

Also, I wish no misunderstanding to occur by the formation of a false idea that these notes recommend sudden and unpremeditated extensions of pruning cycles. Far from this being the case, they must

be read as advising the adoption of longer runs only after every care has been exercised in making sure that certain chosen fields are capable of remaining in a state of vigour throughout an extra period. Some areas of poor tea and bad soil might always be too weak for trial, whilst others would need manuring and working up before any change could be allowed. Indeed, it can now be mentioned that increased lengths of pruning cycles must be taken as questionable for estates of low elevation, or for those subject to such pests as Shot-hole borer.

What is the main argument in favour of increasing pruning cycles as a means to obtain a gain in quality ? The answer to this may be stated briefly as follows:—

By lengthening the period between consecutive prunings the portion of the crop derived from young or tipping leaf is reduced, and that from older and more mature fields is correspondingly increased. As teas manufactured from young field leaf are generally inferior, this alteration in proportioning should cause improvement in quality to take place.

The statement is, I know at variance with other schools of thought who are apt to cling to the rather thin hypothesis that quality will fall away unless bushes are run to some favoured period and no further. Their arguments appear to centre round three beliefs which I will tabulate and then examine:—

(1). That leaf from the final year of an unextended cycle is superior in quality to leaf from the final year of an extended cycle.

(2). That the crop of an estate is unduly reduced.

(3). That recovery after pruning is adversely affected.

To take the first, providing the bushes are maintained in a vigorous state during the last year of an extended cycle, I have not found the quality of teas manufactured from their leaf to suffer; certainly they appear to have a different character with possibly thinner liquors, but the maintenance of flavour, pungency, and brightness more than compensate for this. In any case a comparison with teas manufactured from leaf of the final year of an

unextended cycle is unfair, the examination should be made with teas from leaf of the first year of plucking; after all it is this unwanted leaf which is being supplanted and no other.

Next comes the question as to whether the yields from bushes during the final stages of an extended cycle must necessarily be extremely low. Although I am certain in my own mind that healthy well-manured bushes, if carefully plucked, need not fall off in yield to any appreciable extent, I must admit that certain fields which came under my observation gave disappointing results towards the end of their extended runs. This, however, I attribute to the lack of preparaion for the extension, which was only decided upon a few months before the completion of the normal cycle, and necessitated considerable cleaning up and breaking back of the plucking surfaces. The truly appalling weather, as was experienced throughout, must also have had an effect of retardation. At the moment yields from fields running on extended cycles are satisfactory and point towards excellent amounts of leaf being gathered before the areas are taken down. It is on this data and the good results obtained from several estates of higher elevation that I have formed my opinions.

Finally, we come to the criticism that extended cycles will have an adverse effect on recovery after pruning. The word recovery can, I think, be used in two senses, the ability of the bush to survive pruning, and the restoration of normal flushing. My experience having been with high grown bushes which have apparently had reserves of carbohydrates in sufficient quantities to overcome the possibilities of death, I am hardly in a position to make a definite statement on the first. I imagine that at lower elevations, where any further tendency to die would be noticeable if it existed, the danger could be surmounted by rim-lung pruning. Regarding the second, I have no personal evidence which points towards an extended cycle delaying a field in coming into plucking, and approximately the same number of days has generally elapsed between pruning and tipping, whether the cycles were extended or not. One remarkable and unexpected incident was observed in a

field which had its cycle extended six months and which came back into plucking some four weeks earlier than was usual. The quickness of recovery was entirely local and probably due to climatic conditions. It did not fail to show, though, that no delaying action could be attributed to the six months' extension.

Another form of argument against extended cycles is sometimes made by those who believe a gain in quality is available, but in such small proportions that the total effect is negligible, and certainly not worth the preparations involved. To answer this it is necessary to consider whether the diminution of the portion of leaf from young fields and the increase of leaf from old fields are both sufficient to make a noticeable difference on the quality of a crop when taken over a period of time. Some figures are enlightening and show that the effect of lengthened cycles on the average of invoices is quite appreciable. Whether this effect improves quality will of course be disputed in other circles; nevertheless, I am sure that within limits it does, and the many reports I have received from tasters during the past two years all tend to make my opinion firmer. These figures can be shown in the following manner.

Length of pruning cycles on any one estate, in years	Approximate average ages of invoices, in weeks
2½ to 3	75/80
3	90/95
3 to 4	105/115

It must be mentioned that the average age is calculated by Whitehead's method, and is taken from the date of pruning.

Having given my arguments in favour of rational increases in the length of pruning cycles, I will now present some opinions which were formed during the adoption of extensions, and the procedure with which the change was handled. We will commence with cultivation and pass on to pruning and plucking, finally ending with a history of those fields which were affected.

Cultivation.—There is little doubt that in order to accomplish a programme of lengthened cycles and to maintain it on an economical basis, liberal artificial manuring is necessary from the time of pruning to the finish of the run. Apart from the obvious desirability of manuring sufficiently to harvest a reasonable amount of crop during the latter part of an extended cycle, good teas demand strong healthy flush and cannot be manufactured from the hard stunted growth and banjis common to a played out field. Incidentally, I think there is every indication that this latter type of leaf has been responsible for several of the criticisms which are levelled in opposition to the adoption of increased runs.

A certain amount of surprise is sure to be present at the suggestion that any increased use of artificials is recommended for a system which claims to be a means of improving quality. I judge the question on my observations, and these have shown me that bushes which have not received sufficient and regular encouragement from the start seem to develop a sluggishness and are unable to respond to the applications of further doses. Of course, if advantage is taken of a liberal programme of artificials, and coarse plucking of the younger fields is contemplated, then quality may suffer. The point to bear in mind is that the artificials are for lengthening the cycles and for maintaining flushing during the extended period, not necessarily, as may be commonly imagined, for the purpose of increasing the crop.

As to whether the manures for encouraging extended cycles can include large proportions of inorganics without harming quality, is at the moment undecided. Providing green mulch is plentiful and incorporated at the time of application, it is hard to prove a case against a normal programme of inorganics bulked with some cheap organic substance to simplify spreading. We must hope that research will find that inorganics are not harmful to quality. Per unit they are so much cheaper than other kinds of fertilisers that the removal of any doubt would greatly encourage further manuring and possibly assist towards increases in the length of many pruning cycles. My

own experiences on this point are interesting. Previous to any thought of extending the pruning cycles the estate was manured with mixtures containing large amounts of organic fertilisers; about a year before the change commenced a more inorganic analysis was decided upon and during the year of first extensions an even greater proportion of inorganic nitrogen was included. A comparison of prices before and after the mixtures were changed would be of no value whatsoever owing to the erection of a new factory during the time of alterations. The significant fact, however, is that the teas made from the new factory have possessed stand-out quality to such a degree that little doubt as to the beneficial effect of extended cycles can be entertained. This in turn has been made possible by artificial manures of fairly inorganic compositoin, and not by mixtures containing large proportions of organic matter, as might reasonably be expected.

Before passing on to certain cultivation, data, a few brief words on the question of shade in relation to pruning cycles may be of interest.

That shade can affect the length of pruning cycles may sound far fetched and therefore hardly worthy of an explanation. Nevertheless, I have found that when it is heavy and the bushes are unable to obtain a normal amount of sunshine, a general setback in the condition of their foliage becomes apparent. Similar to checks caused by lack of cultivation, the bushes seldom seem able to recover sufficiently in strength to run their final period with the vigour necessary for the production of quality teas. Every effort to keep all shade in order appears to be essential and frequent loppings and mulchings should be undertaken.

I will now give some data relating to the cultivation programmes before and after pruning cycles were extended. The analysis of manures and the methods of application will be found in the following lists.

Manures as applied for several years before any extension of cycles was made. The bushes were pruned every three years.

Mixture	Acre Rate per	N. Organic	N. Inorg.	N. Total	Phos. Organic	Phos. Inorg.	Phos. Total	Pot.
Pruning	450	9·25	11·25	20·5	16·50	25·50	42·00	25·0
1st General	550	28·00	13·00	41·0	23·00	9·60	32·60	25·0
2nd General	550	28·00	13·00	41·0	23·00	9·60	32·60	25·0
Totals	1,550	65·25	37·25	102·5	62·50	44·70	107·20	75·0

The pruning mixture was forked in alternate rows with green loppings from shade trees and leaf-fall from prunings. The work was performed shortly after pruning. General mixture was forked in alternate rows with green loppings.

Manures as applied the year before an extension of cycles commenced.

Mixture	Rate per Acre	Organic N.	Inorg. N.	Total N.	Organic Phos.	Inorg. Phos.	Total Phos.	Pot.
Pruning	400	10·50	19·20	29·70	4·0	54·6	58·6	16·5
1st General	400	14·70	16·50	31·20	4·8	14·4	19·2	15·0
2nd General	400	14·70	16·50	31·20	4·8	14·4	19·2	15·0
Totals	1,200	39·90	52·20	92·10	13·6	83·4	97·0	46·5

The pruning mixture was forked in alternate rows with green loppings from shade trees and either freshly slashed green prunings or carefully collected leaf-fall. The work was performed shortly after pruning. General mixture was forked in alternate rows with green loppings when available.

Manures as applied at the commencement of extending cycles and to date two-and-a-half years later.

For three-year unextended cycles.

Mixture	Rate per Acre	Organic N.	Inorg. N.	Total N.	Organic Phos.	Inorg Phos.	Total Phos.	Pot
Pruning	400	7·10	21·50	28·60	4·00	54·60	58·60	16·50
1st General	500	13·80	24·70	38·50	8·00	14·40	22·40	15·00
2nd General	500	13·80	24·70	38·50	8·00	14·40	22·40	15·00
Totals	1400	34·70	70 90	105·60	20·00	83·40	103·40	46·50

For three-and-a-half year unextended cycles.

Mixture	Rate per Acre	Organic N.	Inorg. N.	Total N.	Organic Phos.	Inorg. Phos.	Total Phos.	Pot
Pruning	400	7·10	21·50	28·60	4·00	54·60	58·60	16·50
1st General	500	13·80	24·70	38·50	8·00	14·40	22·40	15·00
2nd General	500	13·80	24·70	38·50	8·00	14·40	22·40	15·00
Ante-Pruning	200	5·52	9·88	15·40	3·20	5·76	8·96	6·00
Totals	1600	40·22	80·78	121·00	23·20	89·16	112·36	52·50

For four-year extended cycles.

Mixture	Rate per Acre	Organic N.	Inorg. N.	Total N.	Organic Phos.	Inorg. Phos.	Total Phos.	Pot
Pruning	400	7·10	21·50	28·60	4·00	54·60	58·60	16·50
1st General	500	13·80	24·70	38·50	8·00	14·40	22·40	15·00
2nd General	500	13·80	24·70	38·50	8·00	14·40	22·40	15·00
3rd General	400	11·04	19·76	30 80	6·40	11·52	17·92	12·00
Ante-Pruning	200	5·52	9·88	15·40	3·20	5·76	8·96	6·00
Totals	2000	51·26	100·54	151·80	29·60	100·68	130·28	64·50

In every case the pruning mixtures were forked in alternate rows with either freshly slashed prunings or carefully collected leaf fall. The work was performed shortly after pruning. General Mixtures and Ante-Pruning Mixtures were forked in alternate rows with green loppings whenever available.

A certain amount of overlapping of the different mixtures between prunings has been unavoidable and must continue until the fields pruned shortly before the change have completed their runs.

Pruning —Assuming that the work is carefully carried out, increased cycles and resultant gains in quality can be effected by two circumstances, namely the seasons during which pruning takes place, and the type of pruning employed.

The first is such a debatable point and is so reliant on locality and climate that any positive ruling would be almost impossible to arrive at. The second, however, is less uncertain and observations have shown that pruning should not be too severe nor too light. The

recovery from very severe pruning must necessarily extend over a period of years and makes the advisability of lengthened cycles extremely doubtful, whilst a light type of work, although excellent for initial cropping, is most conducive to premature closing up of flush.

I favour pruning slightly more severely than is usual and consider extra money can justifiably be spent on this work. More attention should be paid to the removal of dead wood and unprolific branches, whilst any snags can be beneficially cut out. A thorough cleaning up of wounds is also to be recommended, not of course from the point of view of improving quality, but in order to lessen any increased risks of rot or canker.

Apart from these few points there is little to be said and we can assume that ordinary normal pruning methods are practically all that is required.

Plucking.—In general plucking should be so ordered that the bushes are maintained at a workable level and extra care is given to the removal of unwanted leaves and banjis. Strong vigorous tea is liable to become completely out of hand during the final stages of an extended cycle, and unless breaking back is a matter of regular routine, the plucking surfaces will become high and ragged. To rectify such a state the bushes must be subjected to a slash across, a process which has given such disappointing results that I recommend it to be avoided whenever possible.

I think, when commencing an extended programme, the most tedious and difficult task is undoubtedly the formation of new levels and the cleaning up of bushes from those fields which were originally due for pruning. Once a programme has been installed, the bushes belonging to fields with extended cycles can be so easily kept in order from the time of tipping, that such difficulties need never reoccur. The fact of evidence pointing towards the final yields of longer running tea improving as the innovation of increasing pruning cycles proceeds, is surely a sign of the importance of this work.

I have been told that if sufficient manure is available, the removal of unwanted leaves and banjis is quite unnecessary as a means of maintaining crop. The opinion may be true for certain localities but it does not agree with my experiences, which lead me to believe that the task is fairly important for good jât bushes, and becomes imperative for hybrid varieties.

The Introduction of Increased Cycles.—At so early a date it is impossible to give more than a very brief outline as to how the programme of increased pruning cycles was introduced. The data for yields and conclusions arrived at from brokers' reports will also take time before sufficient can be collected for use as general information. I am therefore only able to show a summary of events for the first two-and-a-half years of the change and trust they will be of interest.

Acreage	840
Elevation	4200 to 5000
Jât	About 60% good jât and 40% fairly good hybrid.
Previous Cycles	3 years.
Average Yields	600 lbs. per acre. 500 lbs. per acre restriction.
Plucking rounds	10 to 12 days.
Labour	$1\frac{1}{8}$ to $1\frac{1}{4}$ coolies per acre.
Average rainfall	95 in.
Cultivation	As previously outlined.
Green Manure	Plentiful dadaps, albizzias and grevilleas.

Date of Pruning	Area in Acres	Increase in Months	Yield for extension in lbs. of made tea per acre.	Yield for same period directly before extension in lbs. of made tea per acre	Jât	Recovery in days from commencement of pruning to tipping.	Remarks.
Dec. 32	56	36/42	164	264*	Hybrid	142	The change was decided on too late.
Jan. 33	39	36/48	731	840	Good	140	Bushes ran away otherwise very successful.
June 33	31	36/48	426	498	Good hybrid	135	Heavy breaking back was necessary and set back bushes.
Aug. 33	71	36/42	325*	289	Good	108	An excellent result.

* The increases refer to the original 3-year Cycles only.

Date of Pruning	Area in Acres	Increase in Months	Yield for extension in lbs. of made tea per acre.	Yield for same period directly before extension in lbs. of made tea per acre	Jat	Recovery in days from commencement of pruning to tipping.	Remarks
Dec. 33	43	36/42	138	273*	Good hybrid	139	A very disappointing field where heavy breaking back and poor soil played their part.
Feb. 34	19	36/42	226	314*	Good		A fair result.
June 34	64	36/42	Not yet pruned		Good hybrid		In fair condition.
June 34	32	36/42	Not yet pruned		Hybrid		In fair condition.
Aug. 34	54	36/48	Not yet pruned		Good		Excellent.
Feb. 34	21	36/48	Not yet pruned		Good		Excellent.

For fields where the increase was only six months the comparisons of yields are rather unfair, one extending over the March-May busy season. An asterisk is therefore placed against the yields affected by this period.

Acreages of different cycles for past and anticipated pruning given as totals for consecutive seasons commencing with the year April, 1932 to March, 1933.

Season	No increase	6 months' increase	12 months' increase	Total Pruning Area.
1	146 Acres	56 Acres	39 Acres	241 Acres
2	39 ,,	133 ,,	31 ,,	203 ,,
3	39	96 ,,	75 ,,	210 ,,
4	40	32 ,,	150 ,,	222 ,,
5	Nil	95 ,,	145 ,,	240 ,,
6	Nil	114 ,,	125 ,,	239 ,,
7	Nil	67 ,,	139 ,,	206 ,,

* The increases refer to the original 3-year Cycles only.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD ON 12-4-34.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held in the Ceylon Chamber of Commerce Rooms, Colombo, on Thursday, the 12th April, 1934, at 10-30 a.m.

Present.—Mr. Jas. Forbes (Jnr.) (Chairman), the Director of Agriculture, (Dr. W. Youngman, D.Sc., Ph.D.), Messrs. A. G. Baynham, R. G. Coombe, E. L. Fraser, C. E. Hawes, D. T. Richards. B. M Selwyn, J. W. Thompson, R. R. Muras (Accountant), A. W. L. Turner (Secretary) and by invitation Dr. Roland V. Norris (Director, T. R. I.) and Mr. J. W. Ferguson (Visiting Agent).

Absent.—The Hon'ble the Financial Secretary, Col. T. G. Jayewardene, V.D., M.S.C., and Mr. D. H. Kotalawala, M.S.C.

1. Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 13th January, 1934, were confirmed.

3. MEMBERS OF THE BOARD OF THE T. R. I.

Announced that Mr. D. T. Richards returned from leave on the 19th March, 1934, and relieved Mr. F. A. Bond, who had been acting for him.

It was decided to thank Mr. Bond for his services.

The Chairman welcomed Mr. Thompson and Mr. E. L. Fraser, who had been nominated by the Ceylon Estates Proprietary Association to act for Messrs. J. C. Kelly and I. L. Cameron, who proceeded on furlough on the 28th February and 21st March, respectively.

He added that Mr. Thompson would proceed on furlough on the 2nd May, and as Mr. Kelly was returning to the Island shortly after that date, the Ceylon Estates Proprietary Association had renominated Mr. Kelly to act on the Board until Major Oldfield's return in August.

Finance Sub-Committee.—Announced that Mr. Thompson had acted for Mr. Kelly on this Sub-Committee, and the latter gentleman would be asked to resume his seat on his return to the Island.

4. FINANCE.

(a) The Chairman stated that since the last Meeting the Accounts for December, 1933 and January and February, 1934, had been sent to each member of the Board.

(b) *Audited Statements of Accounts for 1933.*—The Accounts were considered satisfactory and approved.

(c) *Election of Auditors.*—Messrs. Ford, Rhodes, Thornton & Co. were unanimously re-elected Auditors.

(d) *Water Supply.*—The Chairman was authorised to obtain details of a scheme for improving the Water Supply at St. Coombs. This appears to be an urgent matter owing to the amount of sickness which has been prevalent amongst those living on the Institute's property.

Mr Coombe stressed the urgency of the matter and suggested that the proposed scheme should be drawn up as soon as possible and circulated to the Members of the Board for comment.

The Chairman suggested that it would be quicker if the Finance Sub-Committee were authorised to deal with it.

This was agreed to.

(e) *Additional Votes: Kjeldahl Room.* The Director reported that one of the fume cupboards was worn out and it was impossible for anyone to work in the room when certain experiments were in progress. As the fumes were very acid, a fan made of incorrodible metal was necessary. The cost thereof would be approximately Rs. 150/-, and the total cost of the necessary alterations would amount to about Rs. 500/-.

The expenditure was authorised.

(f) *Rs. 300/- under Estate Item 34—Pests.*—It was pointed out that there were a number of areas on the estate from which root disease was spreading. It was estimated that accurate mapping of these areas and treatment of the same would cost approximately Rs. 300/.

The additional vote was granted.

5. TEA CESS

The Chairman stated that the Planters' Association of Ceylon had already supported the suggestion that the Cess should be maintained at 14 cents and he had written to the Ceylon Association in London, the Ceylon Estates Proprietary Association and the Low-Country Products Association asking for the support of these Associations.

He pointed out that at the moment one officer was in charge of the Entomological, Mycological and Plant Physiological Departments, and if the Board wished to retain a full staff of scientists, including an Entomologist, every effort must be made to maintain the Cess at 14 cents, because any reduction would necessitate a reduction of senior staff. He added that the Finance Sub-Committee had discussed the matter just prior to the Meeting of the Board and had unanimously decided to recommend that the Board should do its utmost to ensure that the Cess is maintained at 14 cents until 31st December, 1938.

The proposal was carried unanimously.

6. SENIOR SCIENTIFIC STAFF.

(a) *Entomologist — Mr. C. B. R. King.*—Announced that Mr. C. B. R. King proceeded on 8½ months' leave on the 4th April, 1934, prior to severing his connection with the Institute.

(b) *Plant Physiologist — Mr. F. R. Tubbs.*—This Officer's application for leave as from the 31st October, 1934 to the 3rd August, 1935, in accordance with his agreement was sanctioned.

It was further decided that Mr. Tubbs' agreement which expires on the 3rd March, 1935, should be renewed for a further period of 5 years.

(c) *Tea Technologist — Mr. J. Lamb.*—Announced that this officer took up his duties on the 12th February, 1934.

7. JUNIOR STAFF PROVIDENT FUND.

Election of Trustee in place of Mr. Jas. Forbes (Jnr.).—The Rules of this Fund lay down that the Trustees shall be the Chairman of the Institute, one other member of the Board elected by the Board, the Director of the Institute, the Secretary of the Institute, and one member of the Junior Staff nominated by the Junior Staff.

Prior to Mr. R. G. Coombe retiring from the Chair, Mr. Jas. Forbes (Jnr.) was the Board's nominee and as he had now assumed the Chair, there was a vacancy.

It was unanimously agreed that Mr. R. G. Coombe be elected a Trustee as the Board's Representative.

8. MEDICAL SUB-COMMITTEE.

Announced that the Report of this Sub-Committee had been sent to each member of the Board on the 5th instant (Circular No. A. 9/34).

The Chairman stated that the Finance Sub-Committee had considered the Report just prior to the Board Meeting and had decided that as the suggestion had far-reaching ramifications it would recommend to the Board that the subject be postponed until the next Meeting.

This recommendation was adopted.

9. EXPERIMENTAL SUB-COMMITTEE.

The Chairman stated that this Sub-Committee had met at St. Coombs on the 27th January. The Minutes of that Meeting had been sent to each Member of the Board.

In connection with Pruning Experiments, Dr. Youngman stated that he was quite willing to grant facilities for the continuation of pruning experiments at Peradeniya for a further period of two years.

10. ST. COOMBS ESTATE.

(a) *Superintendent.*—Announced that Mr. J. A Rogers was proceeding on 8½ months' furlough on the 18th April.

(b) *Acting Superintendent.*—Announced that Mr. E. J. K. Garthwaite who had been selected by the Sub-Committee appointed for this purpose, vide Cir. No. B. 4/34, had arrived on the estate on the 9th instant.

(c) *Tea Samples.*—It was decided to write to Messrs. Wilson, Smithett & Co., Tea Brokers, to thank them officially for having complied with the Board's suggestion that quarter pound sample packets of St. Coombs teas should be sent to them for their report and retention of the samples for inspection by those interested in the Institute.

11. PUBLICATIONS.

The Board confirmed its decision, which was taken by circulation of papers (Cir. No. B. 1/34) to the effect that copies of all publications issued by the Institute could be sent free of charge as and when requested to Directors and Proprietors of Tea Estates.

12. ANNUAL REPORT FOR 1933.

Announced that a copy of the Secretary's portion of the Annual Report for 1933 was sent to each member of the Board on the 31st January, 1934. A copy of the Report was sent to the Minister for Agriculture and Lands on the 28th March, through the Director of Agriculture.

13. ANY OTHER BUSINESS.

Under this heading the Secretary was instructed to write to Mr. G. H. Callender and thank him for allowing the Institute to use his private cart road during the time that the St. Coombs cart road bridge was closed for repairs in March.

The Meeting closed with a vote of thanks to the Chair.

A. W. L. TURNER,
Secretary.

NOTICES.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcomed but the Staff may not be free to show them round unless an appointment has been made.

St. Coombs Estate is reached by taking the turn-off opposite culvert marked 28/10 on the Nanu Oya-Talawakelle main road. A signpost has been erected at the turn-off.

Publications.—Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not to the Director's Office.*

ROLAND V. NORRIS,
Director.

EDITORIAL.

INDORE COMPOST.

The conservation and renewal of the organic matter content of the soil has always had a prominent place in the advisory policy of the Tea Research Institute. A perusal of the pages of this journal since its inception, shows that we have on numerous occasions emphasized the importance of organic matter both as an improver of the physical condition of the soil and as a deposit account of valuable nitrogen.

The method usually adopted in Ceylon is that of growing and burying *in situ* leguminous and non-leguminous shade tree loppings and litter, and little trial has been given to the manufacture and use of composts. The publication of Sir Albert Howard's monograph on 'The Waste Products of Agriculture' has recently revived the interest in composts and a number of enquiries have been received asking for particulars of the advantages of, and practicability of manufacturing this material according to the Indore process for estate use in Ceylon.

There are a number of advantages in the use of compost: it enables a proportion of cattle dung to be used and it allows of a large variety of vegetable material to be composted, some of it in quantities that would not be large enough at one particular time to be worth while forking in. The result is a compost of uniform texture and nutritive content, with all the valuable nutritive elements conserved, that can be made available in quantity for application at the optimum time.

At Indore the finished product can be produced at a cost of just over one rupee per ton and its efficacy has been thoroughly tested. On tea estates in Ceylon the main objection lies in the probable cost of production. There is a fundamental difference in conditions. As made at Indore, the process makes use of the waste products of

agriculture which, on a farm devoted to general crops, consist of considerable quantities of the plant remains after threshing, such as bean stalks and pods, cotton stalks, sugarcane trash and straw. The cost of producing and reaping these is borne by the cash crop and is not charged to the process. Under our conditions, however, vegetable material would in many cases have to be specially grown. In any case it would have to be specially garnered and the cost would necessarily be charged to the process, with a distinct increase in total cost per ton of compost.

The Institute, however, feels that the process is worthy of detailed examination and has arranged to co-operate with an estate that has arranged to make 100 tons during the next fifteen months. The whole process will be carefully costed and the technical processes supervised by the Institute's staff, so that a considered opinion can be expressed on the possibilities of this carefully thought-out and novel process under tea planting conditions.

T. EDEN.

A COLD WITHERING EXPERIMENT.

A. H. HALL AND T. GLEN DICKSON.

This article is a description of over two years' effort on the part of the writers to enquire into the natural causes which govern the appearance of flavour in tea.

When first we started our search we commenced by tabulating all the natural causes which, in our opinion, resulted in flavour appearing in the made tea.

We tried to make the data as comprehensive as possible and got opinions as to the cause of flavour from well-known planters in Dimbula, Dickoya, Nuwara Eliya, and Uva, and the Tea Research Stations in Ceylon, and North and South India.

From the outset it became apparent that there were two types of flavour and that each of these was brought out by widely varying atmospheric conditions. These two kinds of flavour can be called "seasonal or district flavour" and "high elevation flavour". Almost every district above a certain elevation has a regular period during which atmospheric conditions combine to produce a distinctive flavour and such flavours can be recognized by an experienced tea taster, who can frequently tell the district of origin. On the other hand the highest elevation estates usually have a certain amount of flavour in their teas; it is true that the amount of flavour varies with the seasons, but the point is that it is never entirely absent at any time of the year.

From preliminary reading and experiments we formed an opinion that many factors such as rate of growth (by this we mean rate of elongation of the shoot and not speed of forming and opening of leaves), composition of manure and soil, age of tea from pruning, density of shade, etc., all influence the degree of flavour in the tea but cannot be in any way initially responsible for its presence there.

We next decided to go into the atmospheric condition prevailing during flavoury periods and accordingly obtained morning, and noon temperatures and humidities from representative estates in Uva,

Nuwara Eliya and Dimbula, during the periods when their best and worst breaks were made during 1932.

The average for each break was taken and the following are the results:—

UVA.

(Elevation 3,000 feet).

1	2		3	4		5	6
	Morning Temperatures		Percentage Humidity	Noon Temperatures		Percentage Humidity	Difference in percentage humidity between morning and noon readings
	6 a.m.			Noon			
	D.B.*—W.B.†			D.B. — W.B.			
(1)	60	57	83	73	63	56	27
(2)	65	64	95	72	68	81	14
(3)	66	63	84	80	69	54	30

(1) Break made 8th to 12th February. Sold @ 1/6½. Market average 1/5¾
(2) ,, ,, 25th to 30th March. ,, @ -/6½. ,, ,, -/7½
(3) ,, ,, 14th to 19th July. ,, @ 1/8½. ,, ,, 1/0¾

DIMBULA.

(Elevation 4,000 feet).

1	2		3	4		5	6
	Morning Temperatures		Percentage Humidity	Noon Temperatures		Percentage Humidity	Difference in percentage humidity between morning and noon readings
	6 a.m.			Noon			
	D.B. — W.B.			D.B. — W.B.			
(1)	63	55	58	77	62	41	17
(2)	73	69	81	74	69	77	4

(1) Break made 4th to 12th February. Sold @ 1/11¾. Market average 1/5¾
(2) ,, ,, 23rd to 30th May. ,, @ -/6½. ,, ,, -/9¼

Column 6 is the significant one as it shows the difference between the percentage humidities of early morning and noon.

* D.B. = dry bulb reading. † W.B. = wet bulb reading.

It can be safely taken that the night dry bulb temperatures fell a few degrees below the readings taken at 6 and 8 a.m. and that the surface temperatures of the leaf at night were probably below the dry bulb temperatures and nearer those of the wet bulb, owing to the heat absorbed by the processes of transpiration and evaporation.

These figures enable us to put forward a tentative theory as to the cause of district or seasonal flavour. Evidently this type of flavour is closely linked with atmospheric temperatures and humidities: diurnal variations of both tend to bring it out.

This view is supported by figures given by the U.P.A.S.I. Experimental Station in S. India, who supply the following average monthly figures for their estate taken over a five years' period.

1	2	3	4	5	6
Month	Mean Minimum Temp.	Mean Maximum Temp.	Humidity 8-30 a.m.	Humidity 3 p.m.	Difference in percentage Humidity between morning & noon readings
Jan.	59	79·5	84·7%	47·1%	37·6
Feb.	60·5	82·9	83·6	45	38·6
March	62·6	85·7	81·5	46·4	35·1
April	66	85·7	85·9	64·7	21·2
May	66·6	82·8	82·6	70·1	11·5
June	65·4	74·5	90·0	87·4	2·6
July	64·8	72·8	91·6	87·7	3·9
Aug.	64·3	73·5	90·5	88·6	1·9
Sept.	63·5	76·4	88·7	81·6	7·1
Oct	63·9	77·3	88·1	79·6	8·5
Nov.	62·9	77·2	89·4	71·9	17·5
Dec.	60·9	77·2	88·7	64·2	24·5

Column 6 is the significant one, showing the difference between the percentage humidities obtained at 8-30 a.m. and 3 p.m.

If flavour follows humidities and large diurnal variations bring it but, then it would be expected that January, February and March, would be the most flavoury months, with the flavour falling off from April onwards and starting to come in again in December. This is a close approximation to what actually happens in that district.

There are districts where little diurnal variation of humidity occurs but where a cold weather spell brings flavour. The Assam and Dooars districts are examples of this. On somewhat the same footing is Nuwara Eliya during the monsoons.

The following are the figures obtained for a representative Nuwara Eliya Estate:—

NUWARA ELIYA.

(Elevation 6,000 feet).

1	2		3	4		5	6
	Morning Temperatures		Percentage Humidity	Noon Temperatures		Percentage Humidity	Difference in percentage humidity between morning and noon readings
	6 a.m.			Noon			
	D.B.	W.B.		D.B.	W.B.		
(1)	55	49	64	67	58	57	7
(2)	62	58	78	73	65	65	13
(3)	60	57	83	66	60	70	13

(1)	Break made	8th to 15th February.	Sold @ 3/0½.	Market average	1/5¾
(2)	,, ,,	11th to 17th April	,, @ 1/4	,, ,,	-/7½
(3)	,, ,,	21st to 30th July	,, @ 2/11½	,, ,,	1/0¾

This cold weather flavour in N. India and throughout the year in Nuwara Eliya, is different from seasonal flavour and is brought out only by low temperatures. It is what we have styled "high elevation" flavour and occurs whenever night temperatures drop to below 60°. Below is a table of the maximum and minimum temperature for Nuwara Eliya taken from *The Tropical Agriculturist*.

Month	Mean Maximum	Mean Minimum
December, 1931.	67·0	52·6
January, 1932.	66·0	45·3
February ,,	70·4	39·5
March ,,	70·1	45·2
April ,,	71·3	48·0
May ,,	63·7	53·8
June ,,	66·8	54·4
July ,,	65·0	54·4
August ,,	68·1	53·3
September ,,	66·3	45·5
October ,,	67·1	54·0

It will be seen that the mean monthly minimum is always below 55° to 60° and this is the critical temperature to which the thermometer must fall at night before high elevation flavour becomes pronounced. Such flavour is unaffected by rain or atmospheric humidities and thus differs from seasonal flavours at medium elevations. These figures explain why there is always some flavour present in Nuwara Eliya teas. Estates quite close to Nuwara Eliya, but lower in elevation and therefore hotter, fail to get flavour all the year round because at certain periods of the year their night temperatures rise above the critical 55° to 60° mark.

We have, however, left out another very important factor which influences flavour to an enormous extent and that factor is wind. It may be said that district flavour at medium elevations occurs in a strict ratio to the amount of wind experienced — the greater the wind the more the flavour and *vice versa* In the table of Uva temperatures, it will be seen that the variation of percentage humidities is nearly as great in February as in July but that the prices secured in July compare far more favourably with market average than those secured in February. The good prices secured in July are caused by the strong dry S.W. Monsoon winds acting on bushes that have already been subjected to some weeks' dry weather. There is never

much wind in Uva during February. High elevation flavour is also affected by wind, which is one of the chief contributory causes to the high prices obtained by Nuwara Eliya estates in July.

Owing to the lack of direct and experimental evidence, it is difficult to find out why wind has such a big effect on flavour, but it seems to us that a strong wind must effect a large decrease in local atmospheric humidities by drying everything up rapidly and so accentuate conditions favourable for the appearance of district flavour; also such wind at high elevations will tend to keep down the temperature of the leaf surface by evaporation and transpiration and so lower its temperature comparative to a day of still air. Wind, of course, also helps to get the best out of the leaf during manufacture for flavour by shortening the withering periods considerably, but we are doubtful if artificial flavour could be induced in leaf already lacking it by means of forced draughts during withering. Wind, also, quickly checks rapid growth but so on the other hand do a lot of other factors, like prolonged wet weather or excessive shade, which cannot in any way be said to bring on flavour, although they possibly may in certain cases increase pungency and quality.

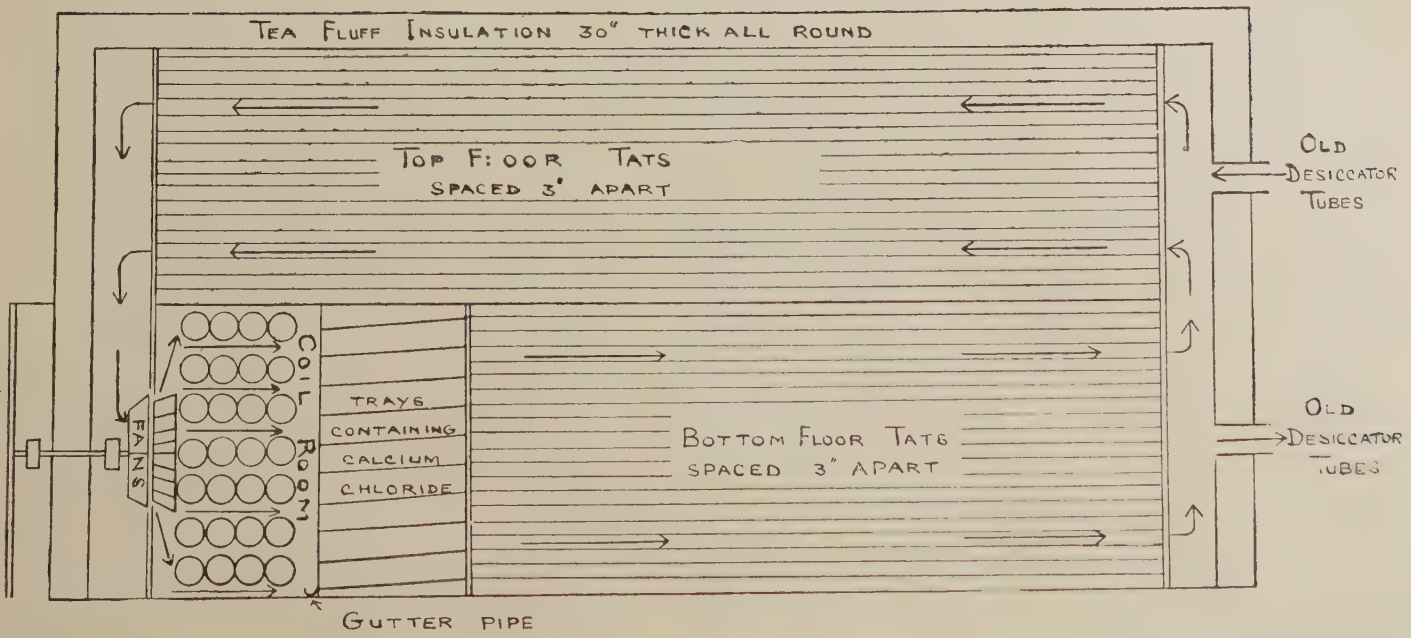
It can be said that Dimbula flavour is a combination of district or "seasonal flavour" and "high elevation flavour", for either dry weather, accompanied by wind, or cold nights will bring it out, and it is at its best on those rare "vintage" years when the two combine together to give cold dry windy weather.

The Dimbula flavour is very quickly dispersed by rain which brings on unsuitable atmospheric conditions of warm nights and high humidities, but on the other hand it is very quickly brought on again by a suitable change in the weather and, therefore, more closely approximates to high elevation flavour than the Uva flavour.

The Uva flavour is evidently of a more permanent type for it will outlast several days of rain and, in fact, is actually said to be improved by a thunderstorm or two in the middle of a long drought, but in contrast it takes many weeks of wind and low humidities to bring it on. It will be seen that the short spells of fine weather in February do not bring it on like the long May to September droughts.

THE COLD WITHERING SHED AS CONSTRUCTED (NOT TO SCALE)

SIDE ELEVATION.



ARROWS DENOTE DIRECTION OF AIR-FLOW.

THE SHED WAS 42' LONG, 15' BROAD AND 14' HIGH ON THE OUTSIDE INCLUDING THE INSULATION.

EACH LOFT WAS 5 1/2' HIGH AND HAD A PASSAGE 3' BROAD RUNNING DOWN THE CENTRE.

THE COIL ROOM WAS 5 1/2' HIGH, 10' BROAD AND 6' LONG.

THERE WERE 10 CALCIUM CHLORIDE TRAYS 5' LONG, 10' BROAD.

THE AIR PASSAGES AT EACH END OF THE LOFTS WERE 3' BROAD.

After collecting this information, it appeared we could get no further until one of us noticed that an overnight break in the S.W. Monsoon accompanied by a clear sky and a fall in temperature appeared to bring out flavour overnight in the leaf withering on the tats, even though such leaf had been plucked in ordinary wet monsoon weather the day before and no flavour had been noticed for a long time in the tats.

Close observation over a considerable period confirmed this and showed that the night temperature had to fall on such occasions to between 55° and 60° before the flavour appeared, and that the lower the temperature dropped, the better the flavour the next day.

Now this coincided with the temperature fall everywhere necessary to bring on high elevation flavour, and we accordingly set out to see if we could get similar results by artificially withering ordinary medium grown leaf in specially conditioned cold air below 60°.

This was a difficult problem and required much thought. Several means of doing the work were possible but all were expensive beyond our means. Fortunately, we were able to obtain a second-hand ammonia refrigerating plant that had been used in a bacon curing enterprise that had failed and this simplified matters considerably.

We could not afford to build a special withering loft outside Kaipoogalla factory and so a place had to be partitioned off in the only available space inside. This was unfortunately next to the driers and in the hottest part of the factory possible, so we were faced with having to cold-wither in a temperature of 90° to 100°.

Moreover, the space available was as strictly limited as our funds and it took endless compromise before a suitable design was adopted.

A sketch of the ulimate design is given on the opposite page, together with details of dimensions for those interested.

The tat area inside came approximately to 8,000 square feet and the tats were only 3 inches apart. They had to be wired to prevent them touching each other when spread with leaf.

500 to 550 pounds of leaf were spread at a time, as this formed, when withered, the minimum charge that could be rolled. It can be imagined that conditions inside with such thick spreading and closely spaced tats were not conducive to either quick or even withers, but it was the best compromise we could come to with the space at our disposal.

In order to keep the cold in and the heat from the driers out, some sort of insulation was necessary and tea fluff was decided upon as the cheapest and easiest obtainable medium. It took about 12 tons of this to form a blanket 30 inches thick all round the outside of the shed. The inside walls of the shed were made of tongued and grooved Lunumidella boards and the fluff was kept in position with hessian.

Two 36-inch Keith Centrifugal fans, running at 700 R.P.M., were employed to circulate the 4,000 cubic feet of air that the shed contained continuously over and over the leaf.

The air after one circuit of the leaf on the two floors was led from the fans over the 1,600 feet of iron coils, through which the cold ammonia was circulating. The air had picked up some heat through imperfect insulation on its run round the shed and was cooled to below dew point on the coils. The condensed moisture accumulated on the coils between defrosting operations as a cover, 1 or 2 inches thick, of snow.

As an additional dehydrant the air was passed, after its passage through the coil room, over trays containing calcium chloride. This liquified in the process of absorbing moisture from the air and dripped off the trays into a gutter pipe which led it outside. The liquid was then collected and the moisture boiled off, when the salt could be used again and the process repeated. In this way about 80 pounds of salt were used daily.

The entrance consisted of double doors within the thickness of the insulation. 12 old desiccator tubes were placed at one end of the shed to form a connection with the outside air, 6 in the lower loft on the pressure side and 6 in the upper loft on the suction side of the fans; so that by opening or closing these tubes, varying

amounts of cold and hot air could be let out and introduced to the shed as a means of temperature control, to prevent the air inside from falling below freezing point.

It took about 12 hours for the compressor to eliminate the heat contained within the weight of metal comprising the 1,600 feet of coils; but once the temperature of the coils was reduced and the fans turned on, the air temperature in the shed fell rapidly and leaf could be charged within a few hours.

When the inside temperature had fallen to about 28° or 30°, the doors were opened, the lights turned on and the 10 o'clock leaf was spread. The heat contained in the 500 odd pounds of incoming leaf, augmented by the heat given out by the lights and the bodies of the spreading coolies, usually raised the temperature up to about 40°, at which temperature the hygrometer showed a difference of about 2° with the high air speeds employed.

When the spreading was finished and the doors sealed up, the thermometer started to drop again and the air pipe connections to the outside atmosphere were employed to keep the temperature above freezing point.

The low temperature combined with the high humidity inside meant that it took a very long time to get a workable wither and we had to compromise in the first instance and take a very light wither of about 60 to 65 per cent. in 24 hours.

The leaf came out of the shed at a few degrees above freezing point and retained the bright green colour of newly plucked leaf. It kept this colour for the first 2 rolls of half-an-hour each and was still cold to the touch at the end of the second roll. Normal rolling temperatures were not reached until the end of the third roll. The leaf was cold enough to cause condensation of moisture on the outside of the roller box during the first roll.

The leaf in the rollers had a peculiarly powerful, although somewhat sickly, smell that could be detected all over the factory. It was just like rolling a charge of freshly gathered tea flowers, but had

the aroma of freshly gathered leaf as well. Evidently the cold air checks some decomposition or fermentation during withering and retains unimpaired the freshness of newly plucked leaf.

It will be readily understood that the abnormally light wither and the small roll charge presented difficulties both in rolling and firing. Owing to the light wither it was not possible to apply normal pressure because the leaf broke up and flaked. This resulted in light liquors and a very flaky appearance to the made tea; the infusions, however, were beautifully even and a bright red colour. There was good nose in the cup and the liquors had definitely improved quality over normal manufacture and nearly always possessed some flavour. It is of interest to record here that we found it impossible to obtain the light green colour and type of infusion commonly associated with flavoury teas and that the liquors invariably tasted sweet, almost as if sugar had been put in them.

Owing to the light wither, in spite of the fact that the drier temperature was raised to the point where quality began to be lost and the infusions dulled, the teas were discharged from the drier with too high a moisture content and we found that they deteriorated and dulled after a week or two. It was not possible to double-fire these teas owing to lack of adequate drier accommodation and they could not be final fired owing to their extreme flakiness.

Colombo valuations for all grades of this experiment, made before the present lack of discrimination for quality teas, showed an improvement of 9 cents a pound over the control. This was an encouraging report in view of the difficulties experienced in manufacture.

We now had to make an attempt to get a better working wither. We first tried obtaining a partial wither in the lofts in a normal manner, and then taking the half withered leaf down and finishing off in the cold shed. We found, however, in this way that no improvement resulted from the use of cold air, there being no flavour at all, and the teas were, if anything, inferior to the control. We had really anticipated this result as we had noticed that a temperature fall had to occur early on at night to effect the leaf on the tats during

flavoury periods. If the fall occurred late at night or during the early hours of the morning, the flavour was not nearly so marked.

We then tried spreading freshly plucked leaf in the cold shed and finishing off the wither in the lofts. After many trials, we found that a certain minimum period of time was necessary for the leaf to remain in the cold shed when it could be taken down and the wither completed in the lofts without loss of flavour, even if hot air was used.

Teas manufactured under this method of withering again showed improvement over the control, but not quite so marked an improvement as the completely cold withered teas.

We do not feel justified, however, in reconstructing this shed on the present state of the tea market owing to shortage of funds.

Although, perhaps, our experiments may have no real scientific value, we hope that these few notes we have made upon them will be of interest and enable others to start on what seems to us quite a profitable line of research.

To sum up, it is apparent that the applications of cold air to freshly plucked leaf during withering causes a totally different set of reactions to take place from those normally experienced.

The flavour brought out by artificially cooled air or naturally cold air during a sudden break in the S. W. Monsoon, is never so pronounced as the flavour that comes on when night temperatures are low over a series of nights and atmospheric conditions have time to effect the leaf growing on the bushes. But the flavour brought out by cold withering is probably, on a normal market and with a perfected withering apparatus, worth about 15 cents a pound and so is well worth considering, provided always that the cost of installing and maintaining suitable plant is not prohibitive. We wonder if this flavour is *brought out* by cold air, or if it is really always there in all leaf at all elevations and is merely *conserved* by the use of cold air and destroyed by air temperatures above 60°.

We are greatly indebted to the Tea Research Institute of Ceylon, the New Colombo Ice Co., Ltd., and the Scottish Tea & Lands Co. of Ceylon without whose help we could have accomplished very little.

TEA TASTERS' TERMS.

J. LAMB.

In all the Arts and Sciences a system of nomenclature becomes a necessity, as soon as any considerable amount of knowledge of the subject is gained. In order that practitioners shall understand what one another are talking about, a standardised system of terms must be used.

The Tea Research Institute has long felt a need for some such system applied to the description of made tea. At present there are a limited number of common and fairly well understood terms, a larger number of alternative terms, and also a host of obscure descriptive words and phrases ranging from the artistic to the vulgar.

With the object of recording the first group, namely the common and understood terms, a conference was recently held between members of the Tea Traders' Association and members of this Institute, and later a glossary of terms was circulated among members of the Association for comment. It is hoped that a system of understandable terms will be of assistance to Superintendents in translating the reports on their teas into something which is of use to them.

There is a definite tendency among tasters to vary their reports by means of synonyms and alternatives. The result is that often the Superintendent does not feel quite certain that he is maintaining the same standard of manufacture. Hackneyed terms may be monotonous but a report should convey exact meanings. Attempts to express the same meaning in different words often defeat their own object.

The valuation is the most concise description. The description in words should be for the purpose of aiding the Teamaker, indicating his strong points in order that he shall know the favoured properties of his teas, and commenting on the faults so that possible lines of improvement are suggested. Let us for this purpose have exact terms, the implications of which are commonly understood and let us omit words and phrases of doubtful meaning. Surely tea is not

such an amazingly complex substance that it is impossible to devise a comparatively few terms to indicate its major properties without doubt as to their exact meaning.

A certain number of terms are quite generally agreed upon, for instance "Light liquors", "Tippy", "Wiry", etc. The great difficulty arises with terms such as "Pungency"; the more serious because it is not a mere question of words but a disagreement among tasters as to the actual occurrence of the feature. Apparently the only general agreement about pungency is that when it is really well marked there is no mistaking it. Some say it has a similar effect to sniffing a bottle of ammonia. From the concensus of opinion of Ceylon tasters there appears to be some doubt as to whether real pungency occurs in this Island. Some tasters state most emphatically that it only occasionally occurs in certain Uva teas during the flavoury season. Others will tell you that it is also found in Maturata and Nuwara Eliya teas, while it is also said to occur in Dimbula.

"Point" appears to be applied by some tasters to a liquor which does not possess real pungency but has a less marked property "on the way to pungency". A "Greenish" liquor characterised by a peculiar bitterness, is sometimes, according to certain tasters, confused with pungency.

A greenish infusion is apt to be misleading, and it seems to be dependent on the district of origin as to whether or not it is a derogatory characteristic. In India, apparently, a greenish infusion damns a tea. In Ceylon it is a characteristic of some of the finest Uvas. General opinion seems to indicate that the word "Greenish" alone indicates unfavourable points but "Bright Greenish" may be quite favourable. This is a term which appears to need a qualifying adjective before it, to establish its full import.

A glossary which has been compiled with the aid of various Ceylon tasters is given below. Further comment on this glossary would be appreciated.

Our thanks are due to Mr. L. C. A. Leefe for drawing up the original glossary and to the Tea Traders' Association and its members who have kindly sent in their comments.

APPEARANCE.

Golden Tip	...	May be bright or dull.
White Tip	...	Silver or Grey tip.
Black	...	Explains itself.
Grey	...	Explains itself.
Well made or well twisted	...	Explains itself.
Even or Uneven	...	Explains itself.
Curly or Shotty	...	Small, round tightly twisted leaf.
Shelly	...	As above but not so tightly rolled, nor completely open or flaky.
Flaky	...	Explains itself.
Grainy	...	Term applied to well made fannings and dust.
Wiry	...	Term used for very well twisted O.P. of thin leaf.
Choppy leaf	...	Shows the use of too much or too small a cutter.
Bold	...	Explains itself.
Mixed	...	Leaf of different grades and size bulked together.
Red Ends	...	Explains itself.
Stalk, Fibre, Fluff	...	Explains itself.
Clean	...	Free from small flaky leaf, fannings, fibre, dust or foreign matter.
Sandy or Gritty	...	Only noticeable when blowing the dry leaf.
Crisp or Biscuity	...	Dry leaf from well fired tea; sometimes slightly highly fired when the term "Biscuity" is used to describe the character of the dry leaf.
Burnt or Overfired	...	Explains itself.
Spongy leaf	...	Dry leaf which is soft to feel, generally due to the absorption of moisture or underfiring.

ADDITIONAL TERMS SOMETIMES USED TO DESCRIBE THE APPEARANCE OF MADE TEA.

Brown	...	Explains itself.
Leafy	...	Used to indicate rather bold leaf particularly in broken grades.
Well made but rather mixed.	...	Probably due to admixture of a different grade to what the tea is marked.

Uneven and Irregular	...	Generally applied to difference in size of leaf comprising one single grade.
Bakey	...	Overfired.
Open Flat	...	Flaky leaf.

INFUSIONS.

Bright, of good colour	...	Coppery or bright gold colour.
Bright but greenish	...	Explains itself.
Bright greenish	...	"Greenish" is not used here in a derogatory sense. Descriptive of some fine Uvas.
Bright but mixed	...	Infusions containing some greenish leaf.
Dull	...	Dark brownish in colour.
Dull green in character	...	Explains itself.
Dull and mixed	...	A combination of the above two.

As a matter of interest it is possible to have an infusion dull in character but with good liquor. Very often the early stages of improvement of Uva teas have this characteristic.

It may also be due to bad firing which has not altogether destroyed the natural quality and flavour in the tea, but has dulled the appearance of the infusion.

LIQUORS.

Flavour	...	Applied to "Up-country" cold weather tea.
Fine and flavoury	...	Explains itself.
Standout	...	Explains itself.
Choice	...	A degree less than above.
Pungent	...	An arresting characteristic when well marked. Of doubtful application to Ceylon Teas. Said to be well marked in some fine Uva "Season" teas.
Point	...	Liquor of good quality with a character on the way to pungency but not as strong or so marked.
Good quality	...	Denotes the presence of desirable characteristics. Most preferably an aggregate or balance of various characteristics with a desirable result.
Malty	...	Useful quality, coloury teas with a touch of high fire.
Good Colour	...	Bright red or golden liquors.

Bright	...	Explains itself. Crystal or Sparkle effect.
Light	...	Explains itself.
Dull	...	Liquors which are not clear or bright.
Brisk	...	Opposite of "Soft". Bright teas is nearly always brisk in character. Also teas which have been correctly fired are geerally brisk.
Smooth	...	Generally a full tea without pungency.
Soft	...	Teas without "Point" or "Briskness".
Flat	...	Same as above.
Thin Good Body or Strength	...	The difference between these terms may be illustrated by the difference between the watery milk and full rich creamy milk.
Full rich teas	...	Same as above.
Washy	...	A dull thin liquor.
Plain	...	Explains itself.
Raw or Harsh	...	Almost explain themselves. Generally teas with too green a character, due to young leaf or under-withering.
Coarse	...	Explains itself.
Greenish	...	A bitterness not to be confused with pungency. Under withered or under manufactured tea. Liable to deterioration.
Tainted	...	Explains itself. Tea having a strange flavour.
Sweaty	...	Taint probably due to overfermentation.

ADDITIONAL TERMS SOMETIMES USED TO DESCRIBE LIQUORS.

Smoky	...	Due to faulty dryer.
Burnt	...	Explains itself.
Sour	...	Explains itself.
Out of Condition	...	Explains itself.
Tatty	...	Tainted by Hessian.
Fruity	...	Tainted by fruit or may be due to too long a process of withering and is noticeable in the lofts when it occurs.
Stewed	...	See Sweaty.
Clean Sweet	...	The term is applied to tea which is literally clean sweet, but of very poor quality.

SOME GENERAL PROBLEMS OF MANURING.*

T. EDEN.

I have recently spoken to District Planters' Associations on the utilisation of green manures; and on the detailed results of our manurial trials at St. Coombs and both these lectures will be given a measure of permanence in the pages of *The Tea Quarterly*. Consequently in response to your Chairman's request that I should speak to you about manuring or green manuring, I have thought it best not to repeat in substance either of those lectures but to fill in the picture somewhat, and I hope by broadening the canvas I shall widen also the discussion which I hope will follow.

The Purpose of Manuring.—I cannot, I think, find a better jumping-off place than by asking you what should be our conception of manuring — what its objects are — and by giving you my answer to that question lead you on to consider how best these aims and objects can be attained.

It seems to me that the whole purpose of manuring is to produce satisfactory crop in satisfactory quantities, and to do so without impoverishing or in any way rendering unsuitable the bushes and soils with which we have to deal. By a satisfactory crop I mean one which is suitable for manufacture into as high class a product as climate and manufacturing conditions allow, and by a satisfactory quantity I mean one which will ensure a profitable return for our outlay. We must avoid the extremes which may give us a high quality product in minimal quantities, or a maximal quantity of low grade tea. I do not conceive it as being my duty as an advisory and experimental agriculturist to adopt Dean Swift's motto and make two blades or leaves grow where one grew before, but to work towards obtaining the kind of crop you want in the quantities you want at the lowest reasonable cost. The former aim is relatively simple where money is no object; the latter is a more complicated and far-reaching problem.

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* A lecture delivered to the Dickoya District Planters' Association on July 19, 1934.

I would specially emphasize the second point in my definition of the purpose of manuring, the one concerned with the maintenance of the bush and soil in good condition. It means that because a soil is good there should be no conscious exploitation of its reserves, that we should strive to put back, so to speak, what we take out or what is lost by natural processes. This is of course an ideal which is practically unattainable, in so much as we can never get the plant to take only what we add to the soil. In fact my figures for the nitrogen balance sheet which I drew up in a former lecture show that the soil reserves always provide the bulk of the nutrient used by a given crop. Particularly in this climate it is proverbially hard to maintain a high level of conservation of nutrient resources because our every cultivation operation increases the speed of degradation processes in the soil, thus providing available nutrient for the crop and also inevitably certain losses. But if we have to accept this situation we can at any rate slow down its progress, and one of the first points to be taken to heart is that, if any measure of nutrient conservation is to be attained, we must have in our manure mixtures all the chief constituents. We are continually removing them in crop, and we must continually add them in the form of fertilisers irrespective of whether they seem to give us a crop response or not.

Manurial Ratios.—If we agree so far, that naturally leads us on to the question of what ratios of the chief nutrients, nitrogen, phosphoric acid and potash we ought to employ. I do not think I am overstating the case in saying that there has been up to now no approach to an agreement in this matter. Soil analysis may give us a guide to what nutrients are particularly deficient, but it needs a considerable act of faith to elaborate hypotheses about manurial ratios direct from these analyses. It needs an intermediate stage of accurate field experimentation before anything like safe ground is reached. With this type of work still in its infancy, I am not going to try to settle this vexed question out of hand in this lecture, but I will tell you how far we have got and what plans we have laid for getting further.

First let us consider the problem of ratio solely in the light of crop response. If we try out a large number of ratios we ought to be able to arrive at one which gives us an optimum response. We have worked on these lines for nitrogen and potash. We have taken the three levels of nitrogen 0, 20 and 40 pounds per acre and corresponding levels of potash, and by using them in all possible combinations we have got nine different ratios which are all related to a stable dose of 30 pounds of phosphoric acid. Our effort to 'spot' a winning ratio have been rendered quite unspectacular by the fact that potash gives no response at all over our three-year experiment. Thus it follows that as far as ratio is concerned one is as good as another according to the experimental evidence. Let me here remind you that we are considering only ratio not actual quantities. In a nutshell the case is that a ratio of 40 N. to nil potash is as good as 40 N. to 40 potash *as far as crop response is concerned*, but that is not the whole story. In three years we are removing quantities of potash in both flush and wood. I have no final figures for wood at present but these are being determined in my laboratory at this moment, but I have figures for flush and every 100 pounds of made tea contains 1·6 pounds of potash. So if your 40 pounds of nitrogen gives you a 700 pounds crop per annum, 11·2 pounds of potash disappear permanently and nothing less than this proportion of potash is consistent with the conservation of nutrients I have urged previously. A guess which is not entirely a guess because it is based on data to hand as yet incomplete, puts the wood figure for this size of crop at 5 pounds and so I suggest that the figure of 20 pounds is a safer figure to work on at this level of crop.

As a tentative method of arriving at a ratio for potash and nitrogen I would therefore say calculate your crop per annum and apply 2·5 pounds for every hundred pounds of tea produced, this figure making what allowance we can on present data for wood as well as tea.

There is one other point about ratio. It is common to find ratios changed in different years of the pruning cycle. Our experimental evidence gives no support to this practice. As for future

plans, we have now included phosphoric acid in our variable quantities, using 0, 30 and 60 pounds per acre. We shall therefore henceforward have 27 ratios to deal with, and I think that should give us a good practical lead in the matter of ratio.

Relative Costs of Manures.—We cannot go very far in our enquiry without considering cost of manure. If there is one thing that depresses me more than another, it is the common practice of talking about manurial doses as so many hundred pounds, without consideration of what those poundages represent in useful food material. We never add nitrogen, potash or phosphoric acid, alone; they are always in combination with other materials and so 400 pounds of this, or 500 pounds of that, means nothing in terms of utility or price. We have about a dozen different forms of nitrogen to choose from and somewhere about the same number of possible sources of phosphoric acid, and there are four or five types of potash compound. They differ in price per ton, and what is of real importance in price per unit of useful foodstuff. It is usual to calculate the unit price of say nitrogen for these various kinds, by dividing the cost per ton by the percentage composition. This figure is actually the price of 22·4 pounds of the nutrient (not the manure) and hence a comparison of unit prices tells one immediately which is the cheapest manure. I will illustrate this supposing that we are dealing with a manure mixture supplying per acre nitrogen 40 pounds, phosphoric acid 30 pounds and potash 20 pounds; and that using the cheapest forms of the last two we are considering what kind of nitrogenous manure to use. We shall find that of those in extensive use, sulphate of ammonia is cheapest. We can then calculate the cost of the other mixtures and find how much dearer they are.

The following figures are the increases in cost per acre, based on recent quotations, which these other kinds of nitrogen would entail for exactly the same amount of nutrient.

	Increase cost per acre for standard mixture
	Rs.
Nitrate of Soda	6
Groundnut cake	10
Bloodmeal	17
Castor cake	21
$\frac{1}{2}$ Sterilized animalmeal	21

In the last figure the composition of the mixture is such that only half the nitrogen could be supplied in this form and the rest is assumed as being sulphate of ammonia. I am not going to discriminate in detail between these sources of nitrogen further than to point out what is obvious, that some are vastly more expensive than others. Ultimately it is for the user to decide whether, taking every aspect of the case into consideration the benefits that accrue from the use of the higher priced materials balance the increased crop or value of crop. We have not tried them all but we have groundnut cake, bloodmeal and sterilized animalmeal under examination. The figures relating to bloodmeal over the past three years show that the crop harvested is the same as with sulphate of ammonia (for these actual doses considered), that the distribution of crop throughout the cycle is identical, *i.e.*, that no rush of crop follows the use of sulphate of ammonia, and that no consistent differences have emerged in the characteristics of the finished teas.

This point about the distribution of the crop is important. It casts grave doubts on the availability-by-slow-stages view which has already been shaken by Dr. Joachim's work, and whilst it does not settle the inorganics versus organics question, it leaves little room for the specification of mixtures with four or five different types of nitrogen compound in them. If on any grounds you wish to use organics, then stick to one sort.

Methods of Application.—Having decided on the composition of the manure mixture on these general grounds, it is advisable to have a last look at it from one other point of view, its distribution. The benefit of the best manure mixtures can be very much discounted if bad distribution is taking place. Ease of distribution will be affected by the consistency of the mixture. Great improvements in the consistency of purely inorganic manures have recently been made, but substances such as muriate of potash will always remain potentially hygroscopic, and phosphates will always be liable to cake in this climate. For this reason I have advised the inclusion of a 'conditioner', to the amount of about 10 per cent. of the whole, in order to prevent caking. We could add an inert substance like coir dust, but that would increase freight without providing any appreciable

nutrient, and by far the best way is to use the organic nitrogen compounds. Castor cake and bloodmeal are most suitable, and it is surprising how well a little of these answers the purpose. When I speak of a conditioner it must be understood that I mean something that keeps the manure mixture in condition, and not something which has any effect upon the soil. The addition of these conditioners also increases gross bulk and against heavier freight charges there must be set off the improvement in distribution obtained in the field when larger quantities are employed.

We can assume now that we have a balanced manure, easy to handle, at the price we are willing to pay, and next comes the problem of putting it on. Practice in this matter varies, and here I hope you will in discussion give me the benefit of your practical experience. There are one or two fundamental principles in the matter of application which can be deduced from technical considerations, but apart from these, application is chiefly a matter of practical expediency. All methods have disadvantages and it is simply a question of weighing up the *pros* and *cons*.

Dealing first with the technical considerations, deep cultivation is the prime necessity for two reasons: shallow cultivation encourages soil erosion, and however well and instantaneously soil fixes manurial principles, if you lose the shallow top soil containing the manure, you lose the manure. In addition, since a high degree of immobilization takes place especially with phosphate, it is essential to get the manure well into the root range of the plant.

Another important thing to remember is that the motion of soil water in the ground is vertical only, and that unless a hard pan interferes and deflects the downward motion, lateral movement is pretty well ruled out. The most striking demonstration of this is on the Rothamsted grass plots where the use of various manures has changed completely the flora of the various plots during eighty odd years of continuous treatment. There are no paths to separate the plots, but you can draw a dead straight line down the dividing line, with one species of grass on one side and a totally different one on the other, so infinitesimal has lateral motion been.

Now to look at present and past practice in the light of these details; I rule out the scraping in of manures by means of small hand forks or such like implements. With deep forking three possibilities remain: (a) general broadcasting, (b) distribution over limited areas such as a half circle above the bush, (c) placing a stated quantity of manure behind every fold of envelope forking at the time of forking.

The first method has the advantage of getting the manure widely distributed and encouraging wide development of the root system. It also enables the Superintendent to see where his manure has gone. Misapplication of the standard rate is reasonably well visible. Its disadvantage is that with present systems of forking some appreciable proportion remains on the top. I am not afraid of this being washed away, because the corrugated surface is a good hindrance, and with deep cultivation the movement of soil in heavy rain storms soon after application should not normally occur; but I admit that a certain proportion of the manure is not deep seated. I want to propose a method of getting over this to a large exent, a method which is good too for other reasons. Whenever possible combine artificial manuring with forking in of prunings, mulch or actual loppings; lop first, and then distribute the manure on top, so that when the vegetable matter is pushed home into the fold, the adherent manure is carried with it. Apart from this, it is excellent practice to use green stuff or mulch in conjunction with artificial manuring.

The half moon system concentrates the manure on a smaller area, and in forking I doubt whether a larger proportion becomes deep seated; because of what I have said about lateral movement of soil moisture, apart from actual soil wash one cannot expect manure to diffuse very satisfactorily over the rest of the area. The method makes easier I believe the rationing of the manure over the prescribed area, but not its even distribution. The manure-behind-the-fork method would be ideal in a world of perfect workmanship, but more than either of the other methods it lends itself to abuse. As things are it is too easy to dump large quantities in the folds near the manure base and, effectively covered up as it is, detection is not so ready. For this reason I have refrained from recommending it.

All of you know the capabilities of your own workmen, the amount of supervision other than your own, (which has to be diverted in any one day to numerous items of routine), and the degrees of reliance you can place on that subordinate supervision, and if good workmanship in the various methods can be guaranteed that is the main thing bearing in mind the technical points aforementioned.

Time and Frequency of Application.—I have left unmentioned one important question in manuring, that of time of application and frequency of application, and I shall not at present have much to say on that score. I am naturally hesitant to give expression to views which I cannot substantiate by direct experimental evidence or by well authenticated general principles of soil technology and plant physiology. We have this problem well in mind and our experimental work now in hand will give us some information in the near future. In the meantime I must ask your indulgence in the matter, hoping that in what I have said you will find something to guide you in your day to day affairs, or something which you would like further elucidated in the general discussion.

A NOTE ON THE SIZE OF TEA FLUSH.

F. R. TUBBS.

In connection with the pruning investigations now in progress, records have been kept of the size of the flush removed during plucking.

The data to be discussed were collected at St. Coombs, Talawakelle, and at Galatura Estate, Kiriella during a period of two years from pruning

The average dry weight, in grammes, of one individual flush removed during tipping, which was performed three times before the commencement of normal plucking, and during plucking in the first and second years from pruning are shown below.

	Clean	Rim-Lung	Cut-Across	Mean
ST. COOMBS.				
Tippings	0·1245	0·1208	0·1148	0·1200
Flush First Year	0·1013	0·1002	0·0953	0·0998
Second Year	0·0886	0·0884	0·0881	0·0884
GALATURA.				
Tippings	0·1604	0·1641	0·1383	0·1543
Flush First Year	0·1349	0·1350	0·1332	0·1344
Second Year	0·1124	0·1121	0·1114	0·1120

Considerable variation is observable in the figures, and it may be first necessary to point out that these differences cannot be ascribed to differences in the standard of plucking. The supervision of the plucking on the experimental plots was very thorough, and one standard of plucking — namely two leaves and a bud, and bhanji of one soft leaf only was rigidly insisted upon. Practical experience has taught that no matter how rigid the plucking system, jât and age from pruning influence the size of the flush. The flush from a China jât field never attains the size of that from a high jât field, while tipping flush can always be recognised on the tats owing to the large size of the shoots and leaves.

The differences in the size of the flush at the two experimental centres are the most prominent in the table. At all stages, the flush at Galatura was significantly larger than that at St. Coombs, though the differences were not constant, but tended to become smaller towards the end of the period. In other words, the weight of a flush at Galatura decreased more rapidly during the cycle than at St Coombs.

Considering the records from the two centres separately, it is found that at St. Coombs the weight of a single flush was significantly greater in the first year than in the second, but there was no significant differential response to different pruning treatments in the two years. Pruning treatment had a significant effect over the two years, the flush from the cut-across plots being significantly smaller than that from the clean pruned plots. The difference between the clean-prune treatment and the rim-lung treatment was not significant, while that between the rim-lung and cut-across treatments just failed to be significant.

The effect of position within the field at St. Coombs was significant, different blocks producing flush of different sizes. The blocks showed no tendency to vary in the second year from the response made in the first, an exactly similar result to that found at Galatura.

At Galatura the weight of a single flush was greater in the first year than in the second, and again there was no differential response to the three methods of pruning in the two years. The effect of pruning treatment was similar to that recorded at St. Coombs, save that both clean pruning and rim-lung pruning resulted in significantly larger flush than cut-across pruning.

Thus it has been found that at both centres flush size decreased with age from pruning, a trend that is uninfluenced by position in the field or by the method of pruning employed. The examination of the records for individual pluckings indicated that this was not a steady trend. The means for tipping and for successive groups of eight pluckings are shown below, there having been 64 pluckings in the two years from pruning at St. Coombs and 88 at Galatura.

ST. COOMBS.

Tipping	1.	2.	3.	4.	5.	6.	7.	8.
·1200	·0979	·1051	·0973	·0868	·0838	·0892	·0919	·0922

GALATURA.

Tipping	1.	2.	3.	4.	5.	6.	7.	8.	9.	10,	11,
·1543	·1399	·1387	·1322	·1338	·1141	·1119	·1084	·1088	·1195	·1167	·1095

It may be thought that these fluctuations from the tendency for the weight of a flush to fall with age from pruning may have been due to variations in climatic conditions. Comparison of the data from St. Coombs with meteorological data indicated that no correlation with the gross climatic data could be established save in the case of minimum temperatures recorded at 9-30 a.m. These form a rough guide to night temperature. It is interesting to note that a significant small negative correlation of $-0{\cdot}432$ was found between the accumulated minimum night temperatures in the nine nights between pluckings and the weight of a flush at the subsequent plucking. This is in accord with the results obtained from climatological work in other crops and is due to the effect of low temperature in reducing respiration during the night and so increasing the assimilatory efficiency of the plant. A similar correlation of $-0{\cdot}0900$ was found between accumulated minimum temperatures and crop, a value that is quite insignificant. The reason for this is that the weight of crop harvested is determined to a far greater extent by the number of shoots gathered than by their individual size. The number of shoots ready for plucking is to be expected to be more influenced by conditions several weeks before, than by the conditions during the last few days of their maturation period.

From what has been said, it would be expected that there would be little correlation between the size of the flush and the weight of crop gathered, the value of the correlation coefficient found for the St. Coombs data being $+0{\cdot}327$ and for the Galatura data $-0{\cdot}261$, both values being significant. The difference in sign of the correlation coefficient at the two centres is unexpected. It is attractive to postulate that the negative correlation coefficient at Galatura was due to the low carbohydrate reserve in the plant leading to actual competition between the shoots, with the result that when

large numbers of shoots broke into growth, their size was reduced. This possibility, however, needs further investigation before much faith can be placed in it.

Thus weight, minimum night temperature and age from pruning have been shown to exert influences on flush weight, but these factors only suffice to account for about one-third of the total variation, and the conclusion must be drawn that other factors are also at work whose nature is at present unknown.

The positional factor played a significant part both at St.Coombs and Galatura. In other words, the size of the flush varied in different parts of the field. The effect was relatively larger at St. Coombs than at Galatura. The positional variance embodied the effects of differences in soil, jât, exposure and shade in different parts of the field. At Galatura the latter three factors were all very uniform over the whole experiment and one is driven to the conclusion that the fertility of the soil may play a part. At St. Coombs the jât factor undoubtedly entered, the blocks situated on lower jât tea giving smaller shoots than those on higher jât areas. The biggest difference in the weight of flush from different blocks at St. Coombs was between 0·0899 and 0·0965 grammes, a difference greater than the biggest difference between the weights of flush from differently pruned plots, and more than half as big as the difference in the weight of flush in different years. Soil and exposure cannot be ruled out as contributory factors and the difference observed must be recognised to be due to several causes. That differences due to jât alone are, however, quite big, is shown by data obtained by weighing flush obtained from closely neighbouring bushes in a very "mixed" area. The flush from bushes selected from the characters of the mature leaves as of "high" and "low" jât was found to have a mean weight of 0·2464 and 0·1500 grammes respectively at the second tipping.

It is as yet too early to attempt to relate flush size with manufacturing problems, but it is perhaps significant that during the early part of the cycle the flush size falls most rapidly. The Institute has already shown that it is during this period that the tanin content rises, but the relationship of tannin content and the size of the flush remains as yet an unexplored subject.

THE EFFECT OF PRUNING ON THE OCCURRENCE OF TEA TORTRIX *(HOMONA COFFEARIA).*

F. R. TUBBS.

During the latter part of 1932, the occurrence of tortrix on the pruning plots at St. Coombs rendered necessary the collection of eggmasses in a systematic manner over the area. Arrangements were, therefore, made to record the number of eggmasses removed from individual plots, fifty-four in number, each consisting of two hundred and fifty bushes. Eighteen were pruned in September, 1931, just before the commencement of the 1931-1932 tortrix season, eighteen in January, 1932, at about the peak of the tortrix season, and eighteen during May, 1932, when tortrix was dying down. Comparison of the degree of infestation of the plots during the 1932-1933 tortrix period enabled the effect of pruning at three periods during one tortrix period on the severity of the attack during the subsequent tortrix season to be gauged.

Visual observation during the early part of 1932 showed that some tortrix appeared on the plots pruned in September, 1931, and less on those pruned in January, 1932, but the numbers were so small that no collections were made. These tortrix owed their appearance either to re-infection of the areas from surrounding tea or to survival on those plots in which the method of pruning did not involve the removal of the whole of the leaves present on the bush.

The total numbers of eggmasses collected from each series of eighteen plots between 17th. September and 19th. December, 1932 are shown below:—

Month Pruned	September, 1931.	January, 1932.	May, 1932.
Percentage of mean Number of eggmasses	4,835 122·2	4,523 114·3	2,513 63·5

Differences of 768 eggmasses (or 19·4 per cent) are significant, and it is, therefore, concluded that there is no significant difference between the number of eggmasses removed from the plots pruned in the previous September and January, but that significantly more were removed from both than from plots pruned in the previous May.

Tortrix attack in the year following the year of pruning was thus diminished by pruning at the end of the tortrix period. This effect did not hold throughout the period under examination, as is shown by the diagram, in which the number collected from each of the three series of plots are shown. It will be seen that external factors resulted in a large decrease in the severity of the tortrix attack about the beginning of December, and that this affected the more heavily infested plots more than those lightly attacked. As a result, the differences between the three series tended to disappear. It will be noted that when an increase in the numbers subsequently occurred, the attack increased uniformly on all three series. Thus the effects of time of pruning were terminated by the first occasion on which adverse external factors resulted in a large decrease in tortrix. This is borne out by subsequent collections during 1933, when no difference was detectable between the series. Pruning at different times can, therefore, only be said to have a limited value as a weapon against tortrix.

The block variance was very strongly significant, indicating the presence of large differences in the degree of infestation between areas of 2,250 bushes (approximately three quarters of an acre).

The effects of the types of pruning employed is of interest. The numbers of eggmasses collected from the plots were:—

Type of Pruning	Clean	Rim-Lung	Cut-Across
Number of Eggmasses	3,653	4,051	4,167
Percentage of Mean	92·3	102·4	105·3

The differences are not significant, but a significant interaction is found between the type of pruning and the time at which it was performed. This is illustrated by the following figures, in which the

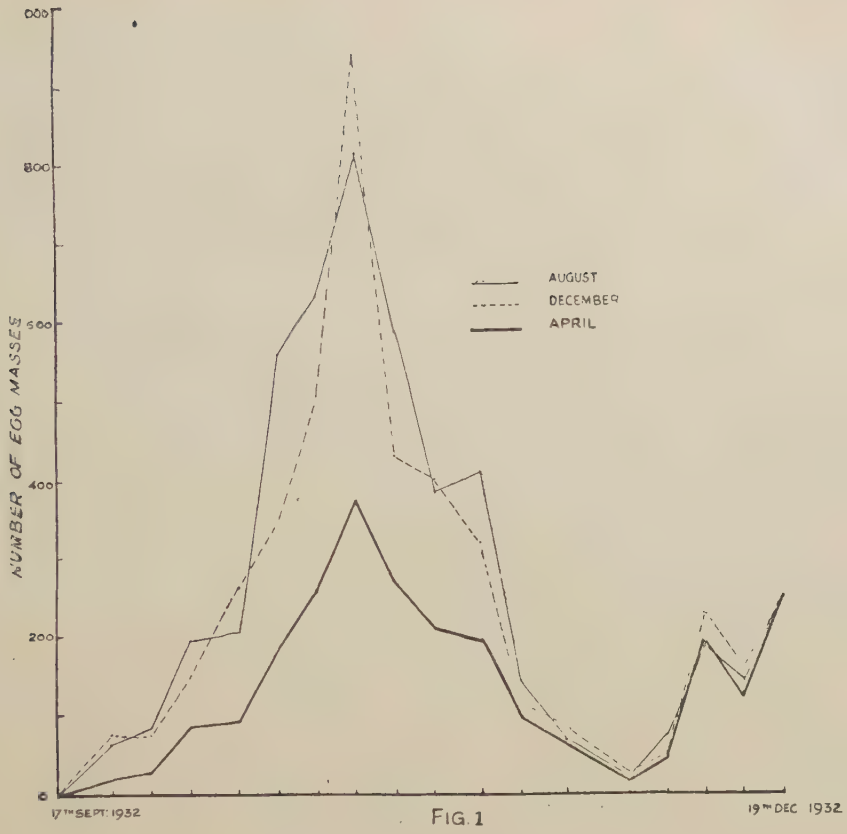


FIG. 1

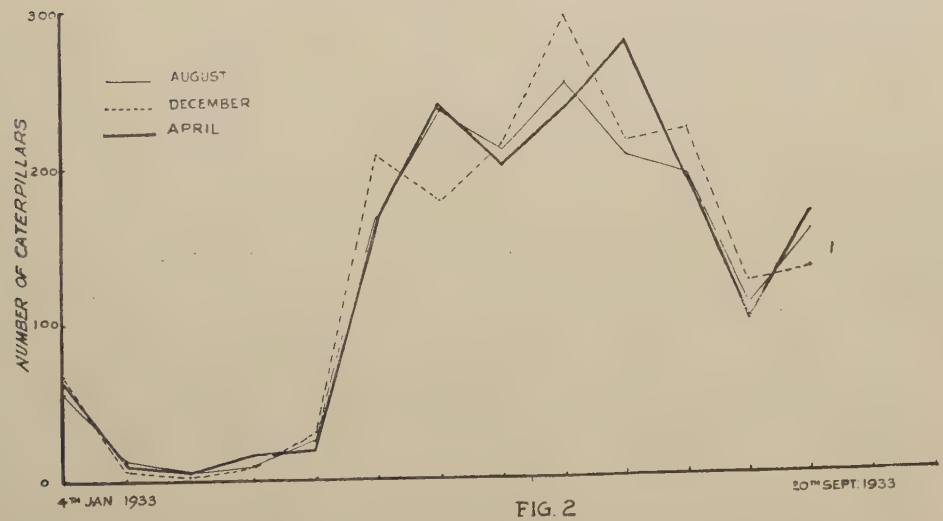


FIG. 2

Fig. I.—Number of egg masses collected during the second tortrix season after pruning.

Fig. II.—Number of caterpillars collected prior to the third tortrix season after pruning.

totals for the rim-lung and cut-across plots are expressed as a percentage of the appropriate clean-prune total.

Time of Pruning	September, 1931.	January, 1932.	May, 1932.
Clean Prune	100	100	100
Rim-Lung	149·4	85·6	116·9
Cut-Across	152·5	85·0	105·6

It appears that if pruning is to be done at the commencement of a tortrix season, clean pruning is to be preferred to any form of pruning in which leaves are left on the bush. It is fortunate that tortrix attacks do not occur at those lower elevations where it is essential that a sufficient leaf area is left on the bush at the time of pruning to enable the bush to recover satisfactorily.

There is not sufficient evidence available to say which is the most important source of a new attack of tortrix — either the rapid increase of a few survivors from the previous season *in situ*, when conditions once more become favourable to them, or the migration into the area of fresh insects from infested tea in the neighbourhood. There is, however, evidence in the results recorded that the former method of origin may play an important part in fresh attacks. This evidence warrants examination.

The existence of marked differences in the degree of infestation on adjacent plots which were only five rows wide, and on adjacent blocks of only three-quarters of an acre, suggest that, though migration of the moth does undoubtedly occur, its effective rate of movement is small.

In the 1932-1933 tortrix season large numbers of mature leaves suitable for eggmass deposition existed on all plots, and yet it has been seen that the time of pruning during 1931-1932 had a significant effect on the distribution of tortrix in 1932-1933. If the attack originated from invading moths during the early part of the 1932-1933 season this result was not to be expected. If more survivors were to be present at the commencement of the 1932-1933 season on the plots pruned in September, 1931, a smaller number on those pruned

in January, 1932, and least of all on those pruned in April, 1932, as appears possible in view of the visual observations in the early part of 1932 already recorded, the differences in survival number would result in different degrees of infestation during the early part of the 1932-1933 season — a result which was actually observed.

It is common to hear the remark that tortrix has 'disappeared' from such and such a field. This can rarely, if ever, be considered to be literally correct. Tortrix grubs were found and collected on the pruning plots throughout the south-west monsoon of 1933. Their frequency is shown in the second diagram. It will be noted that there was no consistent difference to be detected between the numbers of grubs on the plots pruned at the three different seasons.

If, as appears likely, these few survivors in each field play any large part in the initiation of attacks in the succeeding tortrix season, it follows that care in tortrix collection should not be relaxed even in the height of the south-west monsoon. The "Pests and Diseases" vote is usually of small dimensions and will not cover the cost of collections all the year round. However, the caterpillars are a stage in the life-history of the pest that is particularly easy to detect, since they feed on the young flush. The plucker is, therefore, the person in the best position to deal with tortrix during the periods when it occurs in only very small numbers. If only they can be trained to kill each caterpillar in a damaged flush, the number of survivors after a monsoon would be greatly reduced. Too often, when not in the immediate vicinity of a supervisor, damaged flush is just cast aside, and the caterpillar is left to reclimb the bush and perpetuate its species. Actual experiment has shown that tortrix grubs do reclimb the bush after being placed on the ground.

One disconcerting point arises from the data presented, and that is the relative inefficiency of eggmass collection by podians. Indubitably, if *all* eggmasses are collected, the attack would soon cease, but this is realised to be impossible as long as costs have to be considered. But the fact that the eggmass collections did not quickly reduce the attack to an equal degree of severity in each plot indicates the number of eggmasses overlooked was definitely greater

in heavily infested than in lightly infested plots. This can only be interpreted as a weakness in the method and it appears that much more stringent supervision of the labour used in eggmass collection is necessary if the desired results are to be obtained.

HALF-YEARLY REPORT OF THE SMALL-HOLDINGS OFFICER

(JANUARY-JUNE, 1934.)

DEMONSTRATION WORK.

The villages in Uda-Nuwara and Uda-Palata have been visited every month or alternate month. On these occasions inspections are made of holdings worked directly under my guidance as well as others in the neighbourhood. Every opportunity is taken of getting into touch with owners and workers on small-holdings with a view to persuading them and helping them to adopt the type of cultivation, drainage and pruning advocated by the Institute. Demonstrations are carried out whenever possible.

GREEN MANURES.

The adoption of green manures by small-holders is spreading very rapidly following the good example set by the large company estates. The more common of these are the Dadap, Gliricidia and Boga medeloa.

TEA RESTRICTION.

Since writing my last Report, I find that Restriction has brought prosperity to the small-holder, tea coupons being saleable. Coupons will continue to be sold until such time as the bought leaf factory owner is able to pay anything over 60 cents per pound of couponed tea — when coupons alone sell at 35 cents. Coupons will be sold while there is a demand for uncouponed leaf.

The majority of small-holders are putting a good deal of this "unearned income" from coupons into their lands; this can be noticed on a visit to any village where there is tea.

Though the small-holder sells his coupon, he still finds that his leaf is in demand; this is another reason why the small-holder cannot afford to neglect his small-holding. On the contrary he produces his maximum, since he stands to gain both ways, by the sale of his coupons and green leaf. For these reasons Restriction has meant real prosperity to the small-holder — in every sense of the word — when he scores by the sale of his coupons, his green leaf, and sometimes by an over-assessment.

GENERAL.

Good progress and systematic work is carried out on a great many small-holdings in my area. A few have pruned their tea and are resting them. Vacancies are being supplied by many.

Pruning on many a holding is being neglected — this is due in a large measure to the great demand that there is for uncouponed leaf — bought by bought leaf factories, with no consideration given for quality.

It has been proposed at a meeting of the District Agricultural Association that a competition be held among the small-holders of Uda-Palata for the purpose of encouraging more small-holders to adopt the new methods of cultivation, etc. This competition would be a great inducement for all small-holders to make rapid progress, which, I think, should be encouraged.

The Chairman of the Institute with the Director spent a morning visiting the small-holdings in May. They were shown round many small-holdings and a bought leaf factory, where the small-holders' leaf is manufactured.

In conclusion, I must thank those who have rendered me assistance and for their willing co-operation in my work.

R. L. ILLANKOON,
Small-holdings Officer.

Gampola, July 14, 1934.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 14-7-34.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held in the Ceylon Chamber of Commerce Rooms, Colombo, on Saturday, the 14th July, 1934, at 10-30 a.m.

Present.—Mr. Jas. Forbes (Jnr.), (Chairman), Col. T. G. Jayewardene, V.D., M.S.C., Messrs. B. M. Selwyn, C. E. Hawes, D. H. Kotalawala, M.S.C., D. T. Richards, J. C. Kelly, E. L. Fraser, J. D. Hoare, A. W. L. Turner (Secretary) and by invitation Dr. Roland V. Norris (Director, Tea Research Institute) and Mr. J. W. Ferguson (Visiting Agent).

Absent.—The Hon'ble the Financial Secretary, the Director of Agriculture and Mr. R. G. Coombe, M.S.C.

Notice calling the Meeting was read.

The Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 12th April, 1934, were confirmed.

1. MEMBERS OF THE BOARD OF THE T. R. I.

The Chairman welcomed Mr. J. C. Kelly who had recently returned from leave. He thanked Mr. J. W. Thompson for the services he had rendered while acting for Mr. Kelly.

Announced that Mr. A. G. Baynham had resigned from the Board because he was shortly retiring from Ceylon. The Planters' Association of Ceylon had elected Mr. J. D. Hoare to fill the vacancy. He added that Mr. Hoare had only been elected the previous day, and he had given proof of his great interest in the Institute by attending this Meeting in response to a telegram sent him the previous day.

A vote of thanks was accorded to Mr. Baynham for his services.

2. FINANCE SUB-COMMITTEE

Mr. J. D. Hoare was elected to this Committee *vice* Mr. A. G. Baynham resigned.

3. AMENDMENT TO ORDINANCE NO. 12 OF 1925

Cess.—The Chairman announced that the Amending Ordinance provided for a Cess of 14 cents per 100 lbs. of exported tea until the 31st December, 1938. It had been passed by the State Council on the 27th June, 1934.

4. SENIOR SCIENTIFIC STAFF

(a) *Director's Privilege Leave.*—Announced that the Director's application for leave out of Ceylon on urgent personal affairs from the 22nd August to 7th October, 1934, *i.e.*, $6\frac{1}{2}$ weeks was circulated to the Board on the 22nd June, and all Members were in favour of this leave being granted.

This finding was confirmed.

(b) *Entomologist.*—The Chairman stated that as the Board was now certain of the 14 cents Cess until the end of 1938, the appointment of an Entomologist might be re-considered. He pointed out that Mr. Redman King's agreement did not expire until the 9th December, 1934, and perhaps the Board would consider his re-appointment.

Mr. King's re-appointment was agreed to unanimously.

(c) *Plant Physiologist — Mr. F. R. Tubbs.*—The Chairman explained that the Finance Sub-Committee recommended that when Mr. Tubbs proceeds on leave on the 31st October, his work should be divided between Dr. Gadd and Mr. Eden.

This was agreed to.

(d) *Acting Entomologist.*—The Chairman explained that Mr. Tubbs had been acting as Entomologist in addition to his own duties as Plant Physiologist and that when he proceeded on leave, there would be a short interregnum between his departure and the arrival of the Entomologist. The Finance Sub-Committee recommended that Mr. Austin should carry on the routine work of this department during the interregnum.

This was agreed to.

(e) *Biochemical Work.*—A vote of thanks was recorded to Mr. T. Eden for having acted as Biochemist before the arrival of Mr. J. Lamb, the Tea Technologist.

5. BUNGALOWS.

The Director reported that the walls of three Junior Staff bungalows were now about 5 feet high and the site for the fourth bungalow had been cut. He added that the new quarters near the Factory had progressed satisfactorily and the work of fixing the roof was in hand.

The affixing of the Institute's Seal to the plans and specifications of the new bungalows was confirmed. The Seal was affixed on the 12th May, 1934.

6. THE VISITING AGENT'S REPORTS ON ST. COOMBS.

The Visiting Agent's Reports, dated the 11th April, 1934, and 29th June, 1934, copies of which had been sent to each Member of the Board were considered separately.

7. CONFERENCE WITH THE COLOMBO TEA TRADERS' ASSOCIATION.

The Director stated that another Conference had been held in Colombo on the 31st May, 1934, when the following matters had been discussed:—

(a) *Tea Tasters' Terms.*—A glossary of the terms used by various tasters had been drawn up and later circulated to Members of the Tea Traders' Association for comment. Many replies had been received and a review of these appears on page 129.

(b) *Tasting of Experimental Teas.*—Methods had been discussed for obtaining greater precision in reports on experimental teas and arrangements made for tasters to meet at regular inervals and examine such teas collectively.

8. CONFERENCE 1935.

The Chairman suggested that the Biennial Conference of the Institute should be held at St. Coombs Estate in February, 1935.

This was agreed to.

The Chairman also expressed the hope that Members of the Board and others would send in suggestions with a view to make the Conference as interesting as possible.

9. SMALL-HOLDINGS.

The Chairman stated that Mr Iliankoon, the Small-holdings Officer had suggested that prizes should be offered to the small-holders in the Uda-Palata Division in order to encourage them to further efforts. He pointed out that no extra vote would be required because such prizes could be given out of the Small-holdings vote.

It was agreed that Rs. 250/- could be set aside for this purpose.

The Meeting terminated with a vote of thanks to the Chair.

A. W. L. TURNER,
Secretary.

NOTICES.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcomed but the Staff may not be free to show them round unless an appointment has been made.

St. Coombs Estate is reached by taking the turn-off opposite culvert marked 28/10 on the Nanu Oya-Talawakelle main road. A signpost has been erected at the turn-off.

Publications.—Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings. Kandy, and *not to the Director's Office.*

In order to complete files of *The Tea Quarterly* two copies of Vol. IV, Parts 1 and 2 are required. Any subscriber who has these for disposal is asked to communicate with the Director.

T. EDEN,
Acting Director.

EDITORIAL.

CONFERENCE.

The Fourth Conference of the Tea Research Institute will be held at St. Coombs on Friday and Saturday, March 1st and 2nd, 1935. The first day will be devoted to papers and discussions, while on the morning of the second day it is hoped that as many planters as possible will visit the laboratories when members of the Staff will explain the work in progress in their sections and discuss the results obtained.

It is, perhaps, desirable to emphasize that the object of these conferences is not merely to enable the Staff to deliver a series of papers but rather to provide an opportunity for general discussions on matters of interest to the industry.

It is hoped, therefore, that visitors will co-operate in making the Conference a success by participating freely in such discussions.

A full programme of the Conference will be issued shortly, but it may be mentioned here that the subjects to be dealt with will include a discussion on drought conditions in relation to tea culture. The exceptional climatic conditions of the past few months have given rise to problems concerning tea culture both for estate Superintendents and the Scientific Staff of the Institute. Although opportunities have been freely afforded the Staff to examine drought affected areas, it is felt that the whole position cannot be thoroughly reviewed without a full discussion in which estate Superintendents can express their views and give an account of their experiences. The subject will be dealt with in its broadest aspects, special attention being paid to soil cultivation and pruning problems. This discussion should be of interest to all planters, whether they experience drought conditions periodically or not, as the underlying principles are of general importance.

COMPOSTS.

In the present issue will be found an account of the discussion on the Indore process of composting which was held at the last meeting of the Board of Agriculture.

The Institute has continually stressed the importance of increasing the humus content of tea soils and any process designed to utilise waste organic material deserves the most careful examination. As to the merits of the Indore process under conditions of general farming there can be little or no controversy. When applied to such conditions as obtain on the average Ceylon tea estate, the question is largely an economic one — at what cost can the compost be made? This is a problem which is at present under investigation.

DETERIORATION OF TEAS IN TRANSIT.

Complaints continue to be received from time to time in regard to teas "going off" during transit to London. Investigations of these complaints lend still further support to the view already expressed that, in the very great majority of these cases, the trouble is due to the teas being despatched in too moist a condition and could be very largely prevented if the moisture content of every break before packing were determined as a routine measure in all factories. A simple and inexpensive equipment for such determinations is available and it is a matter for regret that it is not more frequently employed. The utility of a moisture determination set is, moreover, not limited to such tests, as much valuable information can be obtained in regard to the different stages of drying and the efficiency of drying machines by its use.

VEGETATIVE PROPAGATION OF TEA.

The question of the vegetative propagation of tea has from time to time been referred to in these columns. The main advantage of such a method of propagation is that plants of uniform character are obtained, whereas propagation by seed leads to the production of very varying progeny.

Vegetative reproduction is practised in Formosa and the subject has received considerable attention in Russia where it has been desirable to obtain and multiply plants highly resistant to frost. The Russian experiments on this subject appear to have been much more successful than similar work so far attempted in other countries and the attention of our readers is directed to an article by Professor T. K. Kvarazkhelia of the Russian Tea Research Institute which appeared in the October number of *The Tropical Agriculturist*.

BOOKS.

Two books of interest to planters have recently been published. In "Notes on Tea Manufacture" (Times of Ceylon Press, Colombo, 1934), Mr. E. G. B. de Mowbray gives an interesting review of his own experiences in manufacture and the views expressed will be found most stimulating and suggestive.

The Publication Branch of the Department of Agriculture, Peradeniya has issued under the title of "A Manual of Green Manuring" (price Rs. 5·00) a reprint of articles published in *The Tropical Agriculturist* by the Staff of the Department of Agriculture.

ROLAND V. NORRIS.

COMPOSTING BY THE INDORE PROCESS

At the meeting of the Board of Agriculture which was held at Peradeniya on November 8th, Mr. Huntley Wilkinson introduced the question of composting, arising out of the interest created in the subject by a pamphlet written by Sir Albert Howard.

Mr. Wilkinson said that, as members would be aware, this subject had received the attention of Ceylon interests in London recently and had been referred to them. His object in asking for its inclusion on the agenda was to give an opportunity to the Tea Research Institute, through their Agricultural Chemist, Mr. T. Eden, to express its views on the subject, which they had taken up very carefully over a year ago.

Mr. Eden: During the past few months considerable interest has been taken in Ceylon in what is generally known as the "Indore" process of composting waste materials for use as manures on estates. The Tea Research Institute has been cognisant of this process for some years and a few months ago arranged with a tea estate in an advantageous position to start an experiment in manufacturing this material. Normally we should have awaited the results of that experiment before making any pronouncement on the subject but in view of the large number of inquiries we have received from estates, and in view of the publicity the process has received in the press and in the State Council, we have decided that the time is opportune to discuss the practical aspects of this process, so that those who wish to give it a trial shall have a clear idea of what such a trial involves.

There are actually two processes, a farm compost process and a night soil process, and these two must be considered separately. Some confusion has arisen because in Ceylon these two processes have been regarded as one and the same. For example, a correspondent in the local press gave details of the night soil process, and in support of that process the paper in question wrote a persuasive editorial which, however, was based on the farm process, which is a rather different proposition.

The farm process makes use of cattle dung, urine-impregnated earth from cattle sheds, litter from these sheds, and a large range of waste materials from agricultural crops. These in definite proportions are fermented in shallow pits, and are given an adequate supply of water, and are turned three times in the process of manufacture. The result is an organic compost of great value. For details, those interested should consult Sir Albert Howard's book "The Waste Products of Agriculture", a lecture to the Royal Society of Arts with the same title, and a memorandum entitled the "Manufacture of Humus from the Waste Products of Tea Estates."

The system was worked out in detail by Howard at Indore under a system of mixed farming of mainly annual crops, and the cost of production was ultimately reduced, according to our latest advices, to fifty cents per ton. It has proved a very valuable process, but what I want to discuss is its application to estate conditions, particularly tea.

There is a great difference between conditions under systems of general farming and under a one-crop culture such as tea. In the first place, mixed farming produces materials such as sugar cane trash, cotton stalks, paddy straw, bean stalks, etc., to quote actual examples, which have to be harvested for crushing or threshing whether they are used for composting or not. *The cost of rearing them and harvesting them falls on the cash crop*, and their wastes are thus free to the composting process. On tea estates, however, no such fortunate circumstances obtain. There are weeds, green manure loppings and the leafy parts of prunings. The cost of rearing these is accounted for but not the cost of transporting them to the manufactory, a much more expensive process on estates which have a minimum of roads for wheeled transport than under the Indore conditions. There is no doubt that, in order to raise a sufficient quantity of material, special crops would have to be grown such as legumes and the cost of these would be chargeable entirely to the process. We fortunately have access to a supply of manna grass, but though this costs us nothing to grow, it costs us about Rs. 2·00 per ton to cut. I have checked up this figure against the

costs of other estates who have made use of it and they are in agreement.

My point is that in the nature of things under estate conditions costs are going to be inevitably high compared with those in Indore. In his memorandum on tea estates, and in a letter to us, Sir Albert Howard admits that recourse to specially grown crops may be necessary. He suggests that costs of running the process can be worked in with other expenditure, but, as a general rule, those of you who know the intricacy of costing under the check-roll system will, I think, agree that what is done will have to be paid for in a direct and uncamouflaged manner.

I will quote two passages from the memorandum on tea, not with a view to discrediting the process, but to show how difficult it is for anyone unacquainted with local conditions to envisage the details of manufacture under circumstances different from those standardised at Indore. "Ample access from the humus factory to the main roads of the estate is also necessary, so that during the carting of the humus to the fields, loaded and empty carts can easily pass one another, and also leave room for the standing carts which are being filled." However much we wish that such conditions were available, those of us who are daily arranging transport along greasy tea paths 3 feet wide must take cognisance of the cost of transport by the only means open to us.

The second passage speaks of the "increased crops of better quality tea which are almost certain to be obtained". My only comment is that here the wish is apparently father to the thought, and that the proof of the pudding is in the eating. There is no evidence that such is likely to be the case, although for a number of years we have been trying to distinguish quality differences due to manuring without success.

In correspondence with us, Sir Albert Howard insists that 750 to 1,000 tons must be produced annually in order to make an economic success of it. Our own experiment of 100 tons admittedly fails entirely to reach an economic level, but when I tell you that 1,000 tons represent the compostible produce from 1,300 acres of

pruned tea, I think you will agree that my estimate conforms very closely to what is practicable on the average estate. My estimate for manufacture and transport to the requisite acreage is about Rs. 8·00 per ton and I hope to be able to reduce it in practice.

If then material has to be specially grown and cut, costs must remain high. If loppings and prunings are to be used, there must be some definite evidence that by transporting to the manufactory and re-transporting to the field as finished compost, an advantage is obtained over that produced by the direct forking now ordinarily carried out. Such evidence is completely lacking for perennial crops capable of assimilating nitrogen at all stages of their life history.

The night soil process consists of composting night soil and domestic rubbish in shallow trenches with the object of providing a manure free from the fly nuisance. I am informed by the Medical Department that a similar if not identical process is used by Urban District Authorities with success and moreover that they anticipate no difficulty through spread of the hookworm organism. If this process is carried on under estate conditions, it assumes a quantity of domestic litter about equivalent to that of night soil. I shall be glad to hear expressions of opinion on whether this amount is likely to be available and on the question of costs of transport of night soil from scattered lines. I would mention that the killing of the hookworm organism during the process would be conditional on the compost being made under optimum conditions of fermentation, for a relatively high temperature is necessary (52°C.).

Many of you are concerned not with tea but with other plantation crops, and I hope in discussion you will give your views on the sources of material you are likely to be able to provide. Any suggestions for cheapening the process will be welcome. It has been my object merely to point out that Indian production figures are not applicable here. Scientific officers are sometimes chaffed about not counting the cost of a process. I have given costs much careful consideration, and as a technical adviser I have thought it my duty to give you such facts and circumstances as I am competent to speak of.

DISCUSSION.

Mr. Huntley Wilkinson initiated the discussion by enquiring of Mr. Eden what proportion of green material he would recommend to be added to 250 tons of cattle bulk manure distributed at ten tons per acre over a block of twenty-five acres.

Mr. Eden replied that the proportion had not been definitely laid down. According to Sir Albert Howard's book a variable quantity of dung could be used provided there was a minimum, not very clearly defined in the book, but which appeared to be about 20 per cent. As far as agricultural value was concerned, from the point of view of estate cattle there was little to choose between dung and compost.

The advantage of the Indore process, as he had stated before, was that it could be carried out free of the fly nuisance.

Mr. E. E. Megget mentioned the instance of how one of the best cultivated and highest yielding estates in his district was found to have suffered more than any other during the recent drought. The Superintendent thought that this might have been the result of the open conditions of the soil owing to the inclusion of quantities of highly organic material which had not had the time to rot down before the drought.

Mr. Eden said that the presence of organic material in the soil should consistently make for the retention of moisture content, that is to say, if the organic matter had had time to rot down into something approaching humus. But if green manure loppings and other waste material were forked into the soil immediately preceding a drought or during drought, the results conceivably would be disastrous. He had come across a number of cases where this practice had been carried on, and the Tea Research Institute had uniformly opposed it.

Mr. Wilmot Perera asked what effect calcium cyanamide had on breaking down the ingredients of a compost or counteracting its nitrogen value.

Mr. Eden replied that the whole idea of composting was to preserve nitrogen, so that the addition of calcium cyanamide to waste material for the making of compost was excellent, provided it was not overdone, and did not infringe existing patents.

Mr. Wilmot Perera said he had just begun the manuring of a 15-acre block with night soil compost and 300 pounds of cyanamide.

Mr. Eden: Are you putting cyanamide into the compost or distributing it as an ordinary artificial manure?

Mr. Perera said he forked in the compost and gave it a dressing of cyanamide at the same time.

Mr. Eden: That is quite all right.

Mr. Wilkinson said he understood that the percentage of nitrogen in compost was proportionately small. He would like to know how much compost Mr. Eden would recommend to give an adequate amount of nitrogen, phosphoric acid and potash per acre; secondly, whether the manurial value of a compost could be determined by the quantity of nitrogen it contained, and, thirdly, what were the advantages of compost over forking in green legumes direct.

Mr Eden said he was afraid he could not answer the first part of the question, that is, he could not say exactly. The ordinary analysis of Indore compost made it out as 1 per cent. nitrogen, but he could not say how much of that nitrogen was in readily available form, nor in what term of weeks or months it would become available. Any nitrogenous manures which contained less than 2 per cent. nitrogen were very slowly made available.

As to the second part of the question — whether it was possible correctly to calculate the value of a compost purely on its nitrogen percentage, the answer was provided by what he had just stated. The nitrogen was there already, but one might be perfectly certain that only a portion of it was readily available. In comparing a manure that normally contained 3 per cent. of nitrogen with one such as compost containing one per cent., the difference in agricultural value was not restricted to two per cent. of nitrogen; there were

physical effects to consider. As to the last part of the question, he did not know of any advantages of compost over the forking in of green manure direct under estate conditions.

Dr. Crawford said that during the past twelve months he had been watching the use of compost on a couple of coconut estates, from which it would appear that many of the objections which Mr Eden had shown to exist on tea estates did not prevail on coconut plantations. He felt that there was a future for compost in coconut cultivation.

One estate he had in mind made the compost on a modification of the Indore process, inasmuch as it did not use urine-impregnated earth, for the reason that it was not possible under dairy conditions to permit the accumulation of effluent in the same way that would be possible when dealing with a shed full of draught cattle. The urine, therefore, was collected in tins. The Superintendent of the estate was very satisfied with the results he had so far obtained.

Besides, on a coconut estate, there were always large quantities of fallen leaves and more weeds and grasses than on tea estates for the making of compost, and, further, the climatic conditions on coconut estates more approximated those of Indore than the climate usually associated with the growing of tea. The other estate used compost, too, but not manufactured on the Indore system. A large shallow concrete pit with a cadjan roof was first constructed. A couple of labourers were engaged during the day to collect any green material they could find and this was placed in a layer at the bottom of the pit. At night ordinary village cattle were driven into the covered pit and tethered there. In the morning the cattle were turned out and the coolies added a fresh layer of green material. The process was repeated and in the end one got a very fine mass of manure. He felt he was not competent to speak on the manurial value of this, but as cattle were involved in the preparation of compost he was, naturally, intensely interested.

Mr. Eden stated that he was very glad to hear of Mr. Crawford's experiences on coconut estates. He had, in his earlier remarks, covered himself by stating that under different systems of cultivation

from tea, there might be some definite advantage to be gained by the adoption of the process. The conditions under which coconut was grown, as stated by Mr. Crawford, were very much better for the process than those relating to tea.

For instance, the problem of transport was simplified by the easier contour of coconut lands. There was also the husk which could be used in suitable proportions in the Indore process. All that he wished to stress was that the problem must be looked at from the point of view of the individual case.

Dr. A. W. R. Joachim, Agricultural Chemist, said that it might interest the Board to learn that during the last eighteen months a considerable amount of work on the subject of compost manure had been done in the Chemical Laboratory of the Department, which would shortly form the subject of an article in *The Tropical Agriculturist*.

From a study of the analytical data, it had been noted that night soil and refuse compost had a manurial value similar to that of cattle manure as obtained locally. The average number of samples of this compost showed a nitrogen content of ·5 per cent., and phosphoric acid and potash contents of about ·3 per cent.

Air-dried compost contained about twice this amount, and, from the point of view of the purchaser, it was advisable to obtain air-dried compost as it would save a great deal on transport charges.

If cattle manure, Dr. Joachim said, was worth Rs. 10·00 per ton, then certainly night soil and refuse compost was definitely worth Rs. 5·00 per ton, which was the price at which it was sold by the Medical Department.

The had also done a number of analyses of composts prepared by the various experiment stations of the Department on the pit process. The manurial value of these was only slightly lower than that of cattle manure and of night soil compost. On the whole, the manurial value of all these composts was approximately the same.

In regard to the investigations made into the night soil composting process, he did not think it necessary to enter into detail, as the results would be published in due course. It was sufficient

to say that the process was one that could not be adopted safely and conveniently by the individual, but municipal corporations should find it a source of revenue, whereas, previously, the disposal of Municipal waste was a source of expenditure.

One reason why the process was not suitable for adoption by the individual was the danger, as indicated by Mr. Eden, of hookworm larvae not being destroyed if the necessary temperature of 52°C. was not reached in the composting process. The Department had advocated the use in villages of the pit composting process. It had, however, been pointed out that these were likely to be sources of danger as potential breeding grounds for the black beetle of coconuts. He was, however, not competent to say much on this subject, which came within Mr. Jepson's particular province.

Mr. F. P. Jepson (Controller of Plant Pests) observed that the possibility of compost pits providing breeding grounds for the Rhinoceros Beetle should not be lost sight of. The beetle was a proclaimed pest and certain measures were prescribed for its control. It bred in decomposing organic matter and consequently the control of such matter went a long way towards the control of the pest. A point to be borne in mind was that the manufacture of compost occupied 90 days and the period during which the Rhinoceros Beetle underwent its development was 150 days. So long as the compost was utilised within this period, there was little danger of its being a breeding ground. Still, as he had stated before, the possibility of the pits being a breeding place for the beetle should not be overlooked.

Dr. R. V. Norris (Director, Tea Research Institute): In order that there may be no possible misunderstanding as to the attitude of the Tea Research Institute towards this process, I should like to emphasise that the Institute has consistently stressed the importance of maintaining and increasing the amounts of humus and organic matter in the soil, and, therefore, any method, such as this Indore Process, which may be put forward for utilising waste material, will be very sympathetically considered by us. As I think you will have already gathered, we have got no criticism to make of this process in the conditions under which it has been used in Indore.

On the contrary, there is no question at all that it is an exceedingly valuable process and under those conditions is going to be very successful. All that we have done is to criticise those results as applied to the conditions as obtaining on tea estates.

The suggestion has been put forward, by implication at any rate, that it should be possible to carry out this process at figures which are comparable to those obtained at Indore. As far as we can see, that is not likely to be realised. As Mr. Eden has told you, we are carrying out experiments, not on the same scale, but on what we consider is as large a scale as practicable under ordinary estate conditions, and we hope to get accurate details as to costing under those conditions. If the costs work out lower than we anticipate now, we will place all the information that we gather immediately at your disposal.

But it is essential, before too high hopes are built that we should get accurate costs, not only in tea, but under varying conditions of cultivation. I do think that the figures given are too optimistic and until the matter is definitely cleared up we must exercise some caution in advocating the process.

Dr. R. Child, (Director of Coconut Research), expressed surprise that Mr. Eden had not criticised more fully the conditions on the first estate mentioned by Mr. Crawford, because the conditions under which a dairy was run were very different to those which obtained in the majority of coconut estates where cattle were kept. It was a matter for careful examination whether composting would give any benefit out of the rough and ready system at present in vogue on coconut estates. The usual practice was to tether cattle and dig trenches into which droppings were dug and covered over with soil.

With regard to waste material available on coconut land, such as fibre refuse, the Coconut Research Scheme had done a large amount of purely chemical work on lignin pentosan ratios of coconut fibre and had come to the conclusion that the ratio of lignin was such as showed that their fears were only too well grounded and that coconut fibre was too ligneous for satisfactory decomposition.

He had had a certain amount of correspondence with regard to the using of green material in connection with fibre in the preparation of compost. But to regard the waste material on coconut estates as the primary source of compost was, he was afraid, to expect too much. He had laid out an elaborate system of experiment and was awaiting the results with a view to ascertaining the rate at which coconut husk broke down in the soil. In correspondence with Indore it had been suggested that greater quantities of nitrogen would perhaps help in the decomposition of husks.

Dr. Child expressed his thanks to Mr. Jepson for his remarks regarding the coconut beetle. If what the sponsors claimed for the Indore process was true, then there was not very much danger, but this depended on the process being carefully and systematically carried out.

Mr. Eden replied by referring to his previous remarks that husks could be used *in suitable proportions*. The carbon nitrogen ratio of Indore compost was high compared with a process such as the Adco process. He had not implied that husks could be used as the primary material. As regards the addition of further nitrogen to aid composting of resistant material, Rege's work had shown it to be of no effect.

The discussion was adjourned until the next meeting, the Chairman expressing, on behalf of the Board, thanks to Mr. Eden for his contribution.

SOME NOTES ON EXPERIMENTAL MANUFACTURE OF MEDIUM-GROWN LEAF AT A HIGHER ELEVATION.

W. A. PALMER.

PRELIMINARY.

Alnwick Estate lies at a mean elevation of about 4,500 feet. The factory lies at an elevation of 3,800 feet. Brookside Estate lies at a mean elevation of about 5,500 feet. The factory lies at an elevation of 5,200 feet. Alnwick Estate had 629 acres in bearing. Brookside Estate had 251 acres in bearing.

OBJECT.

To determine whether leaf from Alnwick manufactured at Brookside would compare sufficiently favourably with leaf from Alnwick manufactured at Alnwick factory to justify a combined factory being built at Brookside to manufacture the crop from both Estates.

PERIOD.

The experiment started on December 5th, 1933 and was concluded on February 24th, 1934.

This period of 80 days was determined by the necessity to make a full sampling break of Broken Orange Pekoe, Orange Pekoe and Pekoe from both sets of leaf. Experimental manufacture took place on every other day, *i.e.*, 40 days out of the whole period of 80 days.

METHOD.

Leaf from Alnwick was harvested daily and on Brookside on alternate days.

On the days when Brookside leaf was being harvested, all the Alnwick leaf was sent to the Alnwick factory to be manufactured; this tea, however, has no connection with the experiment.

On the other days, all the Alnwick leaf was brought to the cart-road to be weighed and half the quantity from each field was sent to Alnwick factory (hereafter referred to as "A" teas) and half was sent to Brookside by lorry, to be manufactured there (hereafter referred to as "B" teas).

The average time taken for the leaf to reach the cart-road was 12 minutes.

The average time taken for the leaf to reach the Alnwick factory from the cart-road was 5 minutes.

The average time taken for the lorry to reach Brookside factory was 47 minutes.

The mean distance from Alnwick to Brookside is 12 miles.

Leaf was spread in both factories at 15 sq. feet per lb. The smallest quantity of "A" & "B" leaf was 605 lb. on December 5th.

The largest quantity of "A" & "B" leaf was 1,750 lb. on February 17th.

FACTORS OUTSIDE THE SCOPE OF THE EXPERIMENT.

(a) *Machinery*.—The teas made at Brookside were fired in a new 3 feet Endless Chain Pressure Drier, whereas those made at Alnwick were fired in an old Down-Draft Sirocco (Dhools) and an old Tilting-tray Drier (Bulk).

All other machinery in the two factories was sufficiently similar to give approximately equal results.

(b) *Artificial Withering*.—Alnwick factory has a 1922 end fans suction system somewhat inadequate in air-speed.

Brookside factory has a 1929 reversible system with excellent air-speed.

(c) *Sites of Factories*.—There must have been some discrepancy in the natural withering facilities, but the factories are on similar sites (both in valleys) and I do not consider the discrepancy important. It was considered that factors (a) & (b), although both favouring teas made at Brookside, were not sufficiently important to account for the marked superiority that these experimental teas showed over teas made at Alnwick.

MANUFACTURE.

At the end of the 40 days of the experiment the total figures were:

	Leaf	Withered leaf	Tea	% of wither	% of made Tea to Withered leaf	% of made Tea to green leaf
	Lbs	Lbs.	Lbs.			
"A"	45,450	22,982	10,475	50·56	45·58	23·00
"B"	44,463	22,385	10,350	50·35	46·23	23·28
	89,913	45,367	20,825	50·46	45·90	23·16

Rainfall "A" 20·13 inches.
"B" 18·28 inches.

In order not to introduce further factors outside the scope of the experiment every effort was made to standardise manufacture in both factories.

Important exceptions to this rule were:

(1) Firing in different types of machines (referred to above).

(2) Different types of artificial withering installations (referred to above).

(3) Fermentation was adjusted according to the temperatures and humidity in the two factories with the object of getting the best result in each.

PROPORTION OF GRADES.

	B.O.P.	O.P.	Pekoe	B.P.	Dust
Alnwick	71·00	13·00	13·25	—	2·75%
Brookside	68·91	12·95	13·27	2·00	2·87%

Invoice No. 23. "A" Teas. Alnwick leaf made at Alnwick.
No. 24. "B" Teas. ,, ,, Brookside.

SAMPLES FOR COLOMBO.

Every few days throughout the experiment samples were sent to Messrs. Cumberbatch & Co., Colombo, for report. Messrs. Cumberbatch & Co. almost invariably preferred the samples from Brookside factory to those from Alnwick factory.

I give below some typical reports:

REPORT OF 5TH DECEMBER, 1933.

"The teas manufactured in Brookside Factory are distinctly preferable to those made in Alnwick, even although the former are lighter in cup and are not so well made in leaf appearance, due to the large percentage of open leaf. We are of opinion that, even with these differences, they would realise better prices than when manufactured in Alnwick factory, but, of course, if it were possible to improve the twist in leaf, we feel that it would be to the Estate's advantage."

REPORT OF 19TH DECEMBER, 1933.

"The 'A' Samples are again quite poor in liquor character, whereas the 'B' teas are brighter in cup with fair strength and have preferable quality."

REPORT OF 29TH DECEMBER, 1933.

"The 'B' Samples again have bright sweet liquors with nice strength and quality and are decidedly preferable to 'A' group".

REPORT OF 28TH JANUARY, 1934.

"The liquors of the 'A' teas are again disappointing, whereas the 'B' range are bright and sweet with fair strength and have nice quality."

EXPERIMENTAL INVOICES.

On conclusion of the experiment:

Alnwick Invoice No. 23 was packed containing the tea manufactured at Alnwick factory (A).

Alnwick Invoice No. 24 contained teas manufactured at Brookside factory (B).

The proportion of grades was as follows:

	B.O.P.	O.P.	Pekoe
"A"	71·00	13·00	13·25%
"B"	68·91	12·95	13·27%

Broken Pekoe and Dust were not packed as the quantities were insufficient.

The Invoices were identical and consisted of:

60 Chests Broken Orange Pekoe
12 ,, Orange Pekoe
12 ,, Pekoe

COLOMBO REPORTS AND VALUATIONS ON ALNWICK INVOICES NOS. 23 AND 24.

Invoice No. 23—"A" teas.—"The liquor of these 3 teas tastes decidedly poor and plain, thus the reason for low normal valuations."

Broken Orange Pekoe	80 cts. (nom.)
Orange Pekoe	77 ,, ,,
Pekoe	78 ,, ,,

Invoice No. 24—"B" teas.—"These teas are bright and sweet in cup with fair strength and nice quality and also have just a slight sign of flavour noticeable."

Broken Orange Pekoe	95 cts.
Orange Pekoe	92 ,,
Pekoe	96 ,,

LONDON RESULTS.

During the course of the experiment a set of bin samples was sent to London comprising the following:

"A" Tea made at Alnwick from Alnwick leaf.
"B" ,, ,, Brookside ,, leaf.
"C" ,, ,, ,, Brookside leaf.

The London Brokers valued these teas as follows:

	"A"		"B"		"C"	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*
Pekoe	1	3½	1	6	1	7
Orange Pekoe	1	3½	1	5	1	6
Broken Pekoe	1	3½	1	4½	1	5½
Broken Orange Pekoe	1	6	1	8	1	9
Dust	1	2½	1	4	1	5

Their comments on the samples were as follows:

"These samples were made in the middle of December, when we think weather conditions were becoming more favourable.

"We think this because the 'C' Samples have more flavour than recent shipments. The most striking feature about the samples is that 'B' samples have flavour and 'A' have not. This alone puts them into a different class, but over and above that, the infused leaf is brighter and the liquor brighter and more pungent.

"The 'C' samples have flavour, brightness and pungency to a still greater extent.

"Against these characteristics, the superior blackness and twist of the dry leaf of 'A' samples and the extra colour in the cup do not count. The appearance of the dry leaf of the 'B' & 'C' samples is quite good enough and much better than it usually is when 'C' gets its highest prices."

Average of	"A"	16·96d.
,,	"B"	18·87d.
,,	"C"	19·87d.

Finally, the experimental invoices were despatched to London on 27th February, 1934 and included, in addition to Alnwick Inv. No. 23 (A) and Alnwick Inv. No. 24 (B), No. 12 invoice from Brookside (C) manufactured on alternate days during the period 10th to 22nd February, 1934 in Brookside factory. These invoices sold at the following average prices:

"A"	Alnwick	No. 23	14·03d.
"B"	,,	No. 24	15·56d.
"C"	Brookside	No. 12	19·04d.

It will be realised that the Brookside invoice had a great advantage over the experimental invoices, in that it was manufactured from 10th to 22nd February in comparatively fine weather, whereas the experimental invoices were manufactured over an 80-day period mainly in wet weather.

I now give the individual reports and valuations received from the London Brokers:

Alnwick Invoice No. 23 made at Alnwick Factory, 4th December to 23rd February, 1934.

60	Chests	B.O.P.	Valued	s.1/3d.	Sold	s.1/2d.
12	,,	O.P.	,,	1/3	,,	1/2½
12	,,	Pekoe	,,	1/3½	,,	1/1¾
		9,600 lb.			Average	14·03d.

Dry Leaf: Blackish, even, well rolled, a fair show of tip.
Liquor: Brisk, rather pungent, of very fair quality.
Infused leaf: Fairly bright.
Bulking: Passed.
Remarks: These teas are about equal in quality to Invoice No. 22.

Alnwick Invoice No. 24 made in Brookside Factory, 4th December to 23rd February, 1934.

60	Chests	B.O.P.	Valued	1/4	Sold	1/3·50
12	,,	O.P.	,,	1/3½-1/4	,,	1/3·50
12	,,	Pekoe	,,	1/4½	,,	1/4
		9,600 lb.			Average	15·56d.

Dry Leaf: Blackish, even, well rolled, a fair show of tip.
Liquor: Brisk, pungent, a little flavour, of good medium quality.
Infused leaf: Fairly bright.
Bulking: Passed.
Remarks: These teas compare favourably in quality to Invoice No. 23 and the out-turns are distinctly brighter.

Brookside Invoice No. 12, Brookside Leaf made in Brookside Factory, from 10th to 22nd February, 1934.

24	Chests	B.O.P.	Valued	s.1/8d.	Sold	s.1/8d.
9	,,	O.P.	,,	1/5	,,	1/5
12	,,	Pekoe	,,	1/7-8	,,	1/6¼
		4,980 lb.			Average	19·04d.

Dry leaf: Blackish, brownish, well rolled, a few tips.
Liquor: Brisk, pungent, a little flavour of good quality.
Infused leaf: Bright.
Bulking: Passed.
Remarks: These teas have slightly more flavour than the last invoice sold per "Oxfordshire".

CONCLUSION.

The Brokers' Reports from Colombo and London taken in conjunction with the average price realised by the "B" invoice of 1½d. more than the "A" invoice, in spite of a very "flat" market, are very convincing.

Throughout the experiment it was most remarkable that the leaf from Alnwick manufactured at Brookside lost many of the characteristics of Alnwick teas and acquired those of normal Brookside teas.

The liquors became lighter with more pungency and quality and there was a marked falling-off in the appearance of the dry tea which became more typical of Nuwara Eliya teas. The infusions, on the other hand, were greener but brighter than in the case of the "A" teas.

It was considered that the only factor which really counted in the experiment was elevation and hence temperature. The "B" teas were manufactured at a temperature normally about 4·2°F. below that at which the "A" teas were made, and this, I believe, was the whole secret of the superiority of the former.

However this may be, the result of the experiment was considered sufficiently convincing to justify the building of an amalgamated factory at Brookside which is now in course of erection.

PLUCKING INDIVIDUAL ROWS.

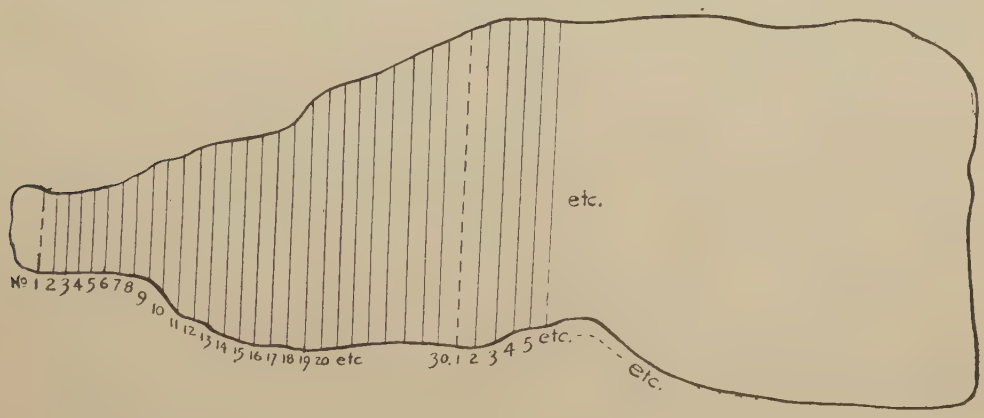
E. R. N. GODFREY.

If one were to tell a modern Rubber Planter that the earliest method of tapping was to put a "gang" of tappers into a field, tap it and then go on to the next, he would be horrified.

"But how could you check bad tapping, bark consumption, etc.?" Quite — one could not, and we very soon changed to the present system of individual tapping blocks. Exactly the same remarks apply to plucking, yet how many estates have numbered rows which the same plucker plucks each round?

Before describing this system I would at once say that there is nothing *new* in it and no originality is claimed.

The easiest way to start is to have a numbered gang on each Division — the number to be decided by the size of the Division. Say that on your Lower Division your average out-turn of pluckers is from 30 to 40, and you decide to make your numbered gang 30. Call in all the baskets and number them 1-30 with paint or tar. After evening muster issue these baskets to your chosen 30 (or draw lots for the numbers). Then allow them to make any changes they like, such as, relations getting next each other etc. Next morning on getting to the field, No. 1 takes up the end row, No. 2 the next and so on up to the 30. Say, No. 3 finishes first she then takes up No. 3 row in the next block.



It will simplify matters at the start if all the No. 1 rows are marked with a whitewashed stone both ends of the row, but after a round or two the pluckers will soon know their own rows and guard them jealously and, if unable to turn out, will send some relation or friend to pluck her row. The advantages of this system are many.

(1) More regular out-turn.

(2) Far less supervision required.

(3) More even leaf, since it does not pay to pluck "arambu" and thus plucking rounds can be kept well up.

(4) No noise and fighting on taking up new rows.

(5) Bad plucking can be traced even weeks later.

It is not claimed that this system works 100 per cent. right, but it is better to have a large percentage of the area well and regularly plucked rather than none.

Now as to the "snags"; you may get 35 or 40 pluckers at muster — send the numbered gang off and, if you have no weeding or other work, send the balance to pluck the old field which you are going to prune next or, if you are 3 short of the necessary 30, draw 3 from the old flush gang or put on 3 men or let those who finished first take up the 3 old rows.

It will be asked what about the good plucker who finishes before the others? If she has not arranged to pluck next to her little brother or sister or old mother she will soon do so.

Irregular fields are no "snag", as will be seen from the above sketch; if Nos. 1 to 6 only have very short rows at the start their next row will be longer. What about supervision when half of them are coming up and others coming down and pluckers are all over the place? Does this matter? As long as they are plucking their own rows they know it does not pay to "strip" or leave the "banji".

In conclusion, in spite of all the "snags", I have always found this system works admirably and is well worth the initial organization.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD ON 14-9-34.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held in the Victoria Commemoration Buildings, Kandy, on Friday, the 14th September, 1934 at 3 p.m.

Present.—Mr. Jas. Forbes (Jnr.), (Chairman), the Director of Agriculture, Messrs. R. G. Coombe, M.S.C., D. H. Kotalawala, M.S.C., B. M. Selwyn, C. E. Hawes, D. T. Richards, J. D. Hoare, R. A. Sharrocks, A. W. L. Turner (Secretary), S. C. Bisset (Accountant) and by invitation the Acting Director, T. R. I. (Mr. T. Eden) and the Visiting Agent (Mr. J. W. Ferguson).

Absent.—The Hon'ble the Financial Secretary, Col. T. G. Jayewardene, V.D., M.S.C., and Mr. J C. Kelly.

1. Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 14th July, 1934. were confirmed, with the following alteration: — 16 — Experimental Sub-Committee, item (c) by substituting the word "breaking" for bearing.

3. MEMBERS OF THE BOARD OF THE T.R.I.

Announced that Mr. E. L. Fraser having resigned from the Board on the 10th August, the Ceylon Estates Proprietary Association had nominated Mr. R. A. Sharrocks to fill the vacancy.

The Chairman welcomed Mr. Sharrocks to the Meeting and said that he would like to thank Mr. Fraser for having served on the Board.

4. SENIOR SCIENTIFIC STAFF OF THE T.R.I.

(a) *Director, T. R. I. — Dr. Roland V. Norris.*—The Chairman reported that the Director had proceeded on $6\frac{1}{2}$ weeks' leave and Mr. T. Eden took up duties as Director until his return on the 7th October.

(b) *Entomologist, — Mr. C. B. R. King.*—The Chairman stated that as mentioned in Circular No. A. 15/34, dated the 31st July, Mr. Redman King had accepted the post of Entomologist. He was due to return on the 18th December but had applied for an extension until the 3rd February, 1935. This extension of leave was required to enable him to carry out some tests with improved forms of spraying apparatus which he is endeavouring to have made for use in Nettle Grub experiments. No additional cost would be incurred.

This application had been circulated to the Board and approved.

This was confirmed.

(c) *Plant Physiologist — Mr. F. R. Tubbs.*—The Chairman said that this officer was proceeding on leave on the 31st October, 1934, and was due to return on the 3rd August, 1935. His leave would actually expire on the 6th August, but owing to the ship arriving three days later he had applied for three days' extra leave.

This was agreed to.

5. HALF YEARLY REPORT OF THE SMALL-HOLDINGS OFFICER.

The Chairman announced that copies of this Report had been sent to each member of the Board on the 24th August, 1934.

Mr. Hoare suggested that as the Field Assistant at Galatura was not fully occupied every day of the week he might visit the small-holdings in the adjoining areas.

The Chairman said that they were going to extend the small-holdings work and he thought that this might be left over till the Director's return.

The Acting Director agreed that the field experiments at Galatura did not now occupy the full time of an Assistant, and he thought that it would be a good idea to go into the matter with Mr. Tubbs when Dr. Norris returned and see how they could fit in this very excellent suggestion of Mr. Hoare.

The Chairman's proposal was agreed to.

The Meeting terminated with a vote of thanks to the Chair.

A. W. L. TURNER,

Secretary.

NOTICES.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcomed but the Staff may not be free to show them round unless an appointment has been made.

St. Coombs Estate is reached by taking the turn-off opposite culvert marked 28/10 on the Nanu Oya-Talawakelle main road. A signpost has been erected at the turn-off.

Publications.—Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not to the Director's Office.*

In order to complete files of *The Tea Quarterly* two copies of Vol. IV, Parts 1 and 2 are required. Any subscriber who has these for disposal is asked to communicate with the Director.

ROLAND V. NORRIS,
Director.

INDEX.

Page

Calapogonium - 116
Calpurnium aurea - 51
Carbohydrate reserves of the bush 5
Cess, T. R. I. 42, 56
Clean pruning — see pruning
Cold Withering - 118
Composts 116, 158, 160, 167
Conference - 157
Cover Crops 51, 93
Cover crops, competition with main crop - 94
Cut-Across pruning — see pruning
Diseases of tea - 51
Dieback - 1, 8
Ephestia kuhniella - 19
Field experiments - 46
Finances of the Institute - 56
Flavour in tea - 118
Flush, influence of pruning on size of - 142
Green Manures 51, 64, 93
Hakea saligna - 51
Indore Composts 116, 158, 160
Leaves, influence on carbohydrate reserves - 6
Machinery, Tea - 43
Manufacture, effect of elevation on - 171
Manures, application of - 138
Manures, Composts 116, 160
Manures Composts, analyses of - 167
Manures, general mixtures 65, 105
Manures, effect on quality 2, 50, 70, 89
Manures, organic and inorganic nitrogenous 11, 50, 91
Manures, pruning mixtures 65, 105
Manures, relative cost of - 137
Manurial experiments 50, 67, 83
Manurial ratios - 135
Manuring of tea - 61
Minutes of the Board of the T.R.I. 31, 37
Moisture content of tea 43, 158
Nettle Grub - 52
Nettle Grub, control of - 53

Page

Nitrogen, effect of increasing doses of - 84
Nitrogen, effect of different types of - 84
Nitrogen, effect on wood production - 87
Oxalis - 98
Plucking - 179
Potash, effect of increasing doses of - 84
Pruning experiments 1, 4, 48, 75, 99
Pruning, increasing length of cycle - 99
Pruning, influence on Tortrix - 146
Pruning, influence of time of 76, 106
Pruning, recovery from - 8
Pruning, rim-lung 1, 7, 75
Rim-lung pruning — see pruning
Recovery from pruning - 1
Shade trees - 93
Small-holdings in tea 55, 150
Tea, culture and marketing of - 28
Tea, diseases of - 51
Tea, deterioration of, in transit - 158
Tea, flavour in - 118
Tea, machinery - 43
Tea, manufacture - 54
Tea manufacture, influence of temperature on - 171
Tea pests - 52
Tea tasters' terms - 129
Temperature, effect of — on carbohydrate reserves - 5
Termites - 53
Tortrix, control of 15, 52, 149
Tortrix, influence of pruning on - 146
Trichogramma erosicornis, field trials with - 15
Trichogramma erosicornis, effect of cold storage on 19
Trifolium subterraneum - 51
Vigna - 98
Vegetative propagation of tea - 158
Wind, influence on flavour - 118
Witches' Broom - 51
Withering experiments - 118

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THE

TEA QUARTERLY

THE JOURNAL

OF THE

TEA RESEARCH INSTITUTE

OF CEYLON.

Edited by

ROLAND V. NORRIS, D.Sc., F.I.C.,

Director, Tea Research Institute.

THE TEA RESEARCH INSTITUTE

St. Coombs, Talawakelle.

PRINTERS H. W. CAVE & CO., COLOMBO.

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CONTENTS.

			Page
1.	Editorial	... ...	1
2.	Tubbs, F. R.	—Pruning in Relation to Estate Profits	4
3.	Eden, T.	—A Question of Policy ...	11
4.	King, C. B. Redman	—An Experiment with Trichogramma and Tortrix	15
5.	King, C. B. Redman	—Cold Storage Effect on *Trichogramma* and on the Eggs of *Ephestia kuhniella.* ...	19
6.	Norris, R. V.	—The Culture and Marketing of Tea (Review)	28
7.	———	Minutes of a Meeting of the Board of the T. R. I. held on 2nd, December, 1933	31
8.		Minutes of a Meeting of the Board of the T. R. I. held on 13th, January, 1934	37
9.	———	Notices	41

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CONTENTS.

			Page
1.	Editorial	... ...	42
2.	Norris, R. V.	—Review of the Activities of the Tea Research Institute ...	45
3.	Forbes, J. (Jnr.)	—The Financial Position of the Tea Research Institute	56
4.	Eden, T.	—The Manuring of Tea ...	61
5.	Tubbs, F. R.	—The Pruning of Tea ...	75
6.	Eden, T.	—A Review of the First Pruning Cycle of the Tea Research Institute Manurial Trials	83
7.	Eden, T.	—The Cultivation of Shade Trees, Green Manures and Cover Crops	93
8.	De Mowbray, E.G.B.	—Increasing the Length of Pruning Cycles	99
9.	———	Minutes of a Meeting of the Tea Research Institute Board held on 12-4-34	110
10.	———	Notices	115

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CONTENTS.

			Page
1.	Editorial	... ...	116
2.	Hall, A. H. & Glen Dickson, T.	A Cold Withering —Experiment	118
3.	Lamb, J.	—Tea Tasters' Terms ...	129
4.	Eden, T.	—Some General Problems of Manuring	134
5.	Tubbs, F. R.	—A Note on the Size of Tea Flush ...	142
6.	Tubbs, F. R.	—The Effect of Pruning on the Occurrence of Tea Tortrix *(Homona coffearia)* ...	146
7.	___	—Half-Yearly Report of the Small-Holdings Officer	150
8.	___	Minutes of a Meeting of the Tea Research Institute Board held on 14-7-34	152
9.	___	Notices	156

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CONTENTS.

		Page.
1.	Editorial	157
2.	Eden, T. & others —Composting by the Indore Process	160
3.	Palmer, W. A. —Some Notes on Experimental Manufacture of Medium-Grown Leaf at a Higher Elevation ...	171
4.	Godfrey, E. R. N. —Plucking Individual Rows...	179
5.	—— —Minutes of a Meeting of the Tea Research Board held on 14-9-34 ...	181
6.	—— Notices.	183

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1935.

Edited by

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Director, Tea Research Institute.

THE TEA RESEARCH INSTITUTE
St. Coombs, Talawakelle.

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CONTENTS.

	Page
Address by the Chairman of the Board given at the Fourth Conference of the Institute	4
Compost Manufacture and Use on Tea Estates by T. Eden ...	79
Diseases of the Tea Bush by C. H. Gadd	132
Editorial Notes by R. V. Norris	1, 75, 122, 168
Further Trial with Trichogramma by C. B. Redman King ...	140
Glossary of Tea Tasters' Terms by R. G. Bradshaw and H. B. Yuille	183
Ground Cover on a Dimbula Estate by C. H. Wilkinson ...	107
Half-yearly Report of the Small-Holdings' Officer, Baddegama January-June, 1935	111
Half-yearly Report of the Small-Holdings' Officer, Gampola January-June, 1935	113
Minutes of Meetings of the Board of the Tea Research Institute ...	72, 117, 163, 203, 206, 207
Notes on Green Leaf Sifting and Fermentation by F. R. Francillon (With Appendix by J. Lamb)	192
Notes on the Supply of Firewood for Tea Estates by H. C. King ...	101
Notices	71, 121, 166, 209
Organic and Inorganic Manures by T. Eden	126
Proceedings of the Fourth Conference of the T.R.I.	4-64
Report on Composting in Relation to Tea Cultivation by T. Eden. ...	151
Report on Test of a Marshall's New Empire Tea Drier by J. Lamb ...	65
Review of the Institute's Programme of Work by R. V. Norris ...	7
Soil as a Water Reservoir by T. Eden	27
Storage and Packing of Tea by J. Lamb	172
Sulphur Taints by J. Lamb	187
Tea Research in Ceylon by F. R. Tubbs	85
Theory and Practice of Tea Drying by J. Lamb	43
Use of Steam in Tea Factories by W. F. A. Ridler	147
Water and the Plant by C. H. Gadd	20

EDITORIAL.

T. R. I. CONFERENCE.

The Fourth Conference of the Tea Research Institute was held at St. Coombs on March 1st and 2nd. The first day was as usual devoted to papers and discussions, and was very well attended, about one hundred and eighty visitors being present. On the second day about forty persons availed themselves of the opportunity to visit the laboratories where members of the staff explained the work in progress in their sections.

It is a pity that more planters do not take advantage of the second day which affords an excellent opportunity for visitors to obtain some insight into the general work of the Institute. Similarly, one would wish that a greater number of persons would take an active part in the discussions of the first day. The object of these conferences is essentially to provide for an *exchange* of views between the staff and the practical planter, but the diffidence of so many visitors in giving expression to their views until *after* the meetings tends to rob the discussions of some of their value.

A full report of the proceedings of the conference is given in this issue.

PACKING OF TEA.

In the course of the discussion on manufacture, the question of the deterioration of tea during transit was raised, and in this connection the view was expressed that the much thinner foils now commonly in use are a contributory cause in many of the cases where such deterioration occurs. To this view the Institute must give its support. Unfortunately, in the press reports of this discussion, the words "tin foil" were throughout substituted for "thin foil". This has not unnaturally led to the quite erroneous conclusion that the criticisms made were specially directed against aluminium foil. In fact, no distinction was drawn in the discussion between different materials from which tea chest linings are made, the point at issue

being simply that these materials, whatever their nature, should be of such a quality as to permit of an airtight and moisture-proof container being formed.

Fresh tea readily takes up moisture and sufficient evidence is available to shew that the amount of moisture absorbed during transit of teas between estates and the London market is not infrequently excessive and detrimental to the keeping quality of the tea. This increase of moisture content is, of course, of particular importance in cases where firing or storage conditions have been faulty, and the teas have initially a relatively high moisture content. For this reason the Institute has constantly stressed the advisability of checking the moisture content of all breaks before packing. The necessity, or otherwise, for final firing can then be determined, and there will be at any rate a guarantee that the tea leaves the estate in a satisfactory condition so far as this point is concerned.

Assuming firing to have been satisfactorily carried out, it is obvious that equal care should be taken to see that faulty methods of packing are not employed.

Without making any invidious distinctions between lead and aluminium or other materials, it may reasonably be asked whether in the search for economy there is not a tendency to employ these materials in a form too thin to give an adequate margin of safety. In this connection the word "thin" is of course a relative term. A thickness which may be quite satisfactory in one material may be entirely inadequate in another. Each material should be considered on its own merits and employed in such a form as will give some guarantee that it will stand up to the conditions of transport, be reasonably free of pinholes and similar defects, and finally be capable of adequate sealing.

During the course of the discussion, reference was made to the possible use of Cellophane as a packing material for tea. A few grades of this material which have been examined by the Institute have been found to be far from impervious to moisture, and hence

unsuitable for the purpose. We understand, however, that a grade claimed to be moisture-proof is on the market, in which case this material will merit further examination.

In stressing above the importance of moisture content on the keeping qualities of tea, we do not wish to suggest that excessive moisture is always the *primary* cause of deterioration. It is known for example that teas dried at too low a temperature do not keep well, this, in all probability, being due to the fact that in such circumstances the enzymes in the leaf are not fully inactivated.

But even in such teas, subsequent changes are to a considerable extent kept in check if the moisture level is not too high. The conditions of packing may thus be a determining factor in such a potentially defective tea.

We would suggest, therefore, that further consideration should be given to the question of packing materials and that the very natural desire for economy should not be pushed too far, resulting in undesirable risks being incurred.

It only remains to add that the Institute will gladly co-operate with the interests concerned in examining such materials as they may wish to test.

ROLAND V. NORRIS.

THE FOURTH CONFERENCE OF THE TEA RESEARCH INSTITUTE OF CEYLON

The Fourth Conference of the Tea Research Institute of Ceylon was held at St. Coombs on March 1st, 1935.

MORNING SESSION.

Chairman:—Mr. Jas. Forbes (Jnr.), Chairman of the T.R.I. Board.

THE CHAIRMAN'S ADDRESS.

My first duty as Chairman is to extend a very cordial welcome to you all, and to express the hope that you will, as on former occasions, co-operate in making the conference a success by contributing to the discussions which are to take place.

I do not propose to occupy more than a few minutes of your time as we have a somewhat full programme before us. There are, however, a few observations which I wish to make.

At the last conference, the Chairman, Mr. Baynham, referred to the financial position of the Institute, which at that time was a matter of very real anxiety owing to the imposition of Tea restriction and the unfavourable condition of the tea market, both of which factors made a very material reduction in our receipts. The position was further complicated by the fact that when the question of the Institute's cess came up before the State Council in December 1933, the rate of 14 cents was reimposed for one year only, to the end of 1934. This naturally left us completely in the dark as to what our further financial resources were likely to be, and in consequence the Board reluctantly came to the decision that a reduction must be made in the scientific staff by the suppression of the Entomologist's post.

Fortunately, the position has improved sufficiently for this decision to be re-considered. The cess has been fixed at 14 cents up to the end of 1938, and receipts from the estate are better. In consequence, the agreement of the Entomologist has been renewed and we are glad to see Mr. King back with us today.

It is imperative, however, in my opinion, that we should continue our efforts to accumulate a considerable reserve for renewal of plant and experimental machinery. We have been considerably hampered in our work on manufacture by lack of such funds and it cannot be doubted that, if St. Coombs factory is to be kept abreast of modern developments, considerable expenditure will be required from time to time.

Capital expenditure on other items will fortunately be much less heavy in the future. Quarters for all the St. Coombs staff have now been completed, and the water supply has been placed on a more secure basis. It is likely, therefore, that for the present further capital expenditure will be limited to the development of work at outstations.

A word in connection with the present conference. I should like to explain what is intended to be the real basis of these meetings. The main object is to provide for a free, full and informal *exchange* of information between the scientific staff and yourselves. You will note I stress the word "*exchange*". The staff, in their papers introducing the various items for discussion, will put forward their point of view based on results and data accumulated from their experiments. We are particularly anxious to hear your comments and constructive criticisms on these opinions, and to receive any suggestions based on your practical experience which may throw light on the matters under discussion. Such an exchange of ideas can do much to maintain a proper perspective between theoretical and practical considerations, and cannot but be helpful both to the scientific staff and to yourselves in whose hands lies the application of methods suggested by the staff.

In this matter I therefore ask for your co-operation without which the conference will lose much of its value.

A further point I wish to stress is the importance of personal contact between the planter and the Institute's staff. A great many visits are paid to estates by the Research Officers, but there is necessarily a limit to expansion in this direction, and I should like to see a considerable increase in the number of visits made by planters to

St. Coombs. I realise that Visitors' Day, the last Wednesday in the month, may not always be a convenient day, particularly to visitors from a distance. The Director will be glad, however, to arrange for visitors to see the work in progress at other times, if reasonable notice be given. In such cases it is desirable that visitors should, if possible, give some indication of the subject they wish to discuss They can then be informed whether the officer concerned will be available on the day proposed.

Another way in which contact might be improved is by the more frequent presence of members of the staff at meetings of District Planters' Associations. The Director will arrange for occasional lectures by the staff if required, but, even without these, the occasional attendance of one of the staff at P.A. meeting would enable personal contacts to be established and, while providing an opportunity for dissemination of further information as to the work of the Institute, would give the staff a greater insight into local conditions and local problems.

Finally, gentlemen, I would like to correct any wrong impressions which may have been conveyed by a very misleading headline in the "Times of Ceylon" last week. In the report of a meeting of the Madulkelle District Planters' Association, at which the Director had made a brief allusion to some small-scale experiment on manufacture, a large heading appeared "From Hock to Bad Burgundy" "London Brokers' Report on St. Coombs' samples".

This, separated from the context, might well convey an impression that St. Coombs' teas had been adversely reported on in London. This, I am glad to say, is entirely incorrect, as our teas are well considered and are realising good prices.

The remark was, of course, merely an amusingly expressed comment on a single experimental sample forwarded for an opinion as to whether the modification under investigation was likely to be of value or otherwise, and had nothing at all to do with our ordinary programme of manufacture.

I call now on Dr. Norris to give his paper.

REVIEW OF THE INSTITUTE'S PROGRAMME OF WORK.

ROLAND V. NORRIS, DIRECTOR.

The Chairman in his address to you has referred to the importance of securing closer contact between the Institute's staff and the planter, and before passing on to discuss more technical matters, I should like to make a few remarks on this point.

TUITION

You will perhaps remember that at the last conference held two years ago, a suggestion was put forward strongly urging the necessity for courses of instruction at the Institute. We have always recognised that work of this kind should ultimately form part of our activities but before incurring the expenditure that such courses would necessitate, it was considered advisable to ascertain if there really were a general demand for facilities of this kind. The matter was accordingly referred to the C. E. P. A. and the Planters' Association for an expression of opinion. The C. E. P. A. was prepared to accept the views of the P. A., but when the matter came up for consideration by the latter body, a resolution was passed that while the principle of the suggestion received their approval, it was not considered that the time was yet opportune for initiating such work. There the matter rests for the moment, and I would only suggest that, if in the interval that has intervened there has been any change of opinion, the matter might well be discussed by District Planters' Associations, and then, if necessary, referred to the Parent Association for further consideration. Such courses, if initiated, will necessarily have to be of short duration, and would consequently be definitely limited in scope. It is not suggested, therefore, that they would provide any basic training in agricultural science. Though it is perhaps outside my province to make such a suggestion, I would ask whether it would not be to the advantage of the tea industry generally if provision were made for some preliminary agricultural training of assistants before arrival in Ceylon. However unpopular the idea may be, I think the fact has

to be faced that planting will have to become more and more scientific as time goes on if we are to hold our own with our competitors, and some provision should be made to meet these conditions. A preliminary training in the general principles of agricultural sciences need neither be lengthy nor expensive, and I think it would amply repay Companies when recruiting staff to make some such provision.

CONFERENCES

Leaving the question of tuition I should say a word about the question of conferences and discussions. The view has been expressed to me on several occasions, that if the conferences were held at some more central place than St. Coombs the attendance would be very materially increased. There would be many practical difficulties in holding the main conferences away from Headquarters, and my own view is that St. Coombs is the most appropriate spot. It might, however, be feasible in the interval between the larger conferences, which as you know are at present held every two years, to arrange for sectional meetings on a smaller scale in districts more remote from St. Coombs, and I should be glad to hear any comments you may care to make on the subject.

EXPERIMENTAL WORK

I will now pass on to discuss shortly the progress which has been made since we met at the last conference, and to indicate in what directions developments are likely in the near future.

As the Chairman has already mentioned, the financial position has been such that a year ago, not only was any further development out of the question, but it appeared likely that some reduction would have to be made in the scale of our activities.

Improved and more stabilised conditions have fortunately rendered this unnecessary, and while any expansion of our work has not been possible, we have been able at least to maintain our original programme, and I think it may fairly be claimed, that in certain directions, results of great interest and economic value have emerged.

MANURIAL EXPERIMENTS

I will refer first of all to the manurial experiments.

These have now been in progress for rather more than three years and have completed a full pruning cycle. This seems an opportune moment, therefore, to sum up the results obtained, though the experiments will of course continue for a considerable further period. You will perhaps remember that the scheme of work was designed to provide information on the following points:—

(1) The effect of increasing applications of nitrogen and potash.

(2) The comparative effect of different *types* of nitrogen, a comparison being made between organic and inorganic nitrogenous manures.

In both cases the question of the *quality* of the tea produced has been examined, as well as variations in yield.

The results obtained have been exceedingly clear cut and consistent, and in view of the period of time covered, which has included very varying climatic conditions, I consider the conclusions reached can be accepted with every confidence. Briefly these are as follows. Nitrogenous manuring, as was of course to be expected, has given consistent increases in yield. The highest amount applied was at the rate of 40 lbs. nitrogen per annum, or 120 lbs. in the pruning cycle, and the results indicate that a further response would have been obtained if higher applications had been made, though whether this would prove generally advantageous is a point for further examination

Potash, on the other hand, has throughout the experiment had no influence whatever on the yield of tea. We are not, however, inclined to advise the total omission of potash from estate mixtures. We know that definite quantities of potash are being removed from the soil by the crop, and though the reserves may at present be adequate, it would appear unwise not to make good this depletion. We have, however, felt justified in reducing the percentage of potash in the mixtures we have suggested, and as this substance is expensive this step will help in reducing cost.

But perhaps you will be more interested in the comparison between inorganic and organic nitrogen as represented by sulphate of ammonia and bloodmeal. The issue has been one of great practical importance during the last few years when economic conditions have in general necessitated drastic reductions in the expenditure on manuring.

The St. Coombs results have shown no significant difference whatsoever, either in regard to yield or in the quality of the resulting teas between inorganic and organic nitrogenous manures when applied in equivalent quantities. With regard to yield this applies not only to the total yearly crop, but also to the distribution of that yield throughout the year, the yield curves running side by side throughout the whole period.

We have no grounds to believe, therefore, that inorganic forms of nitrogen cannot safely be substituted for the more expensive organic varieties formerly in use, though we have always advised that their use should be combined with as intensive a programme of green manuring as may be feasible. Experimental work in North India has led to similar conclusions. In Java there would appear to be a feeling in many quarters that the use of ammonium sulphate has not been advantageous. Judging from such figures as have been at my disposal I am inclined to believe, however, that any detrimental effect obtained there has been the result, not of the ammonium sulphate *per se*, but of the employment of this manure in excessive doses. In other words I anticipate precisely similar results would have been obtained with other forms of nitrogen in equivalent amounts. I hope shortly to have an opportunity of studying this more closely.

At St. Coombs we have not only the results of our experimental plots but two years' experience on the estate as a whole, since inorganic mixtures have been in use since 1933. We have no evidence of any deterioration of the tea, and in regard to quality our present prices would suggest that the 1935 vintage of "hock" is in no way inferior to that of earlier years.

Large numbers of estates have now some experience in the use of inorganic mixtures, and we should be very grateful for an expression of your opinion as to the results which have been obtained,

As orginally laid down, the St.-Coombs experiment was confined to nitrogen and potash. A modification has been introduced in the second pruning cycle to enable a study to be made of the effect of phosphatic manures. This may be of some importance since Indian experiments are suggestive that under certain conditions phosphatic manures may have some influence on quality.

Manurial experiments have also been laid down at Passara. The phosphate question is likewise receiving attention there as is the question of the time of application of the manures under examination. The experiment has not been long enough in progress to justify any very definite statements, and I will only say that so far, higher doses of phosphates have not resulted in any alteration in yield, nor has any significant difference resulted between applications of the material mixtures made two months before pruning, at pruning time, and two months subsequent to pruning.

COMPOSTS

From a consideration of inorganic manures I must swing over to the other end of the scale, to the question of composts. A considerable amount of interest has been aroused during the past year by the Indore method of composting, and we have received many enquiries on this question. The subject has been dealt with in some detail in our publications, and also in an address given by Mr. Eden before the Central Board of Agriculture. But as there appears to be some difference of opinion as to the feasibility, under Ceylon conditions, of the methods suggested, I think I should take advantage of a representative gathering, such as the present, to summarise our views.

First of all, to avoid any possible misunderstanding, it should be clearly understood that there are two quite distinct processes of composting originating from the Indore laboratory. The first of these is for the utilisation of night soil and line refuse, while the second, and one which concerns us most closely, makes use of waste crop residues and vegetation in conjunction with cattle manure and urine-impregnated earth, and litter from cattlesheds. With regard to the night soil process I only wish to say that while it is eminently

suitable for use by municipal bodies and sanitary boards where proper supervision can readily be given, some care may be necessary on estates. Properly conducted, the conditions of composting are such that hookworm ova are destroyed by the temperature attained. On the other hand, if the process be incorrectly carried out the necessary temperature may not be attained and there is some risk of the dissemination of hookworm ova when the resulting compost is used.

Considering the second form of compost, I wish to make it perfectly clear that we have no criticism to make of the method in itself. On the contrary, it is excellent in every way and produces a product of high value. Our warnings are based chiefly on the fact that for reasons which I shall explain in a moment, the conditions on the average Ceylon estate are such that the cost of producing the compost will be very much greater than the figures obtained at Indore; that the quantity which most estates will be able to make is likely to provide for but a small proportion of the area to be manured; and finally that some of the forecasts as to the beneficial effects to be expected from the use of compost with tea are based on a very insecure foundation.

First in regard to the question of cost. Under Indore conditions the process makes use of the waste products of agriculture such as crop residues, and the cost of producing these falls on the crop concerned and not on the compost. Moreover in a flat well-roaded country the cost of transport is small. Under such favourable conditions it has been possible to produce the compost at the very low figure of 50 cents per ton.

On the average Ceylon estate the conditions obtaining are of a very different order. The amount of waste vegetative matter is small, and in most cases, if appreciable quantities of compost are to be made, such material would have to be specially grown for the purpose. Again, transport facilities are poor, very few estates having the road facilities envisaged by Sir Albert Howard. These factors combine to render the process much more costly than is the case in the Indian plains, and before extravagant hopes are formed

as to the utility of this method of composting under tea estate conditions, it is desirable that much fuller data should be obtained as to the cost under Ceylon conditions.

In regard to the supply of compostable material, Sir Albert Howard considers it may be advantageous to utilise the green manures grown in the field, these being lopped, removed for composting and returned again to the field when required. He considers that there are disadvantages in the incorporation of unrotted green material into the soil which would be obviated by this procedure. It will be useful to examine the basis of this point of view. It is largely founded on the conditions obtaining with annual crops. In such cases there are obvious advantages in having a supply of rotted down material ready for use at the most appropriate moment, the reason being that with many of these crops the period during which the crop can advantageously utilize the nitrogen supplied is of short duration. If green manures are applied in the fresh state there is in some cases a risk, if other conditions are unfavourable, that the nitrogen in the material may not be available when required. In the case of a perennial crop such as tea these conditions do not apply. Except possibly for a short period after pruning, the bush makes a continuous use of the nitrogen available, and there is no reason to consider there is otherwise any special period when the nitrogen supply is of greater importance than at other stages of growth. In these circumstances there seems no objection to the direct incorporation of green material *if this be properly carried out*, the nitrogen content of the material being sufficiently high to render decomposition rapid under our climatic conditions with little danger of the locking up of soil nitrogen.

In a time of drought bad results might of course follow the incorporation of such fresh, unrotted material but I am considering the use of green material in an intelligent manner. In further support of the use of composted material, the view has been expressed that this will have a favourable effect on the quality of the tea. I do not know of any evidence at present available which justifies this assumption. Experimental evidence strongly suggests that manuring in any

reasonable quantity has little or no effect on the quality of tea, and it would be unwise, therefore, to anticipate an exception in this case until there is some definite evidence to support the hypothesis.

The question would, therefore, appear to resolve itself into the two considerations (1) What amount of compost can an average estate produce? (2) At what cost can this be made?

We are co-operating in an experiment on an estate in the preparation of about 100 tons of compost, and accurate costings are being made. It is possible that it may be feasible to increase this quantity but under the most favourable circumstances the total amount producible will not exceed a maximum of 500 tons. The estate is one of about 1,000 acres on a two years' pruning cycle. Even should the maximum amount indicated above be produced, you will note this quantity will only provide for a small proportion of the area to be pruned annually. But the experiment will at any rate serve to provide figures of cost. I should mention, however, that Sir Albert Howard considers even the larger quantity of 500 tons an uneconomic experiment. In his opinion the unit should be at least 750 tons and preferably 1,000. I can only say that if this is so, this figure will rule out the vast majority of Ceylon estates.

PRUNING

I must now leave the question of composts, however, as I wish briefly to summarise some of the results which have been obtained from our pruning experiments.

As you know these are being carried out at three different centres — St. Coombs, Peradeniya and Galatura. Mr. Tubbs at the last conference put before you some of the preliminary data obtained from the first year of the experiment. The point of greatest practical importance that had already become apparent then was the extremely beneficial results obtained by the use of rim-lung pruning at low elevations. The experiments have now been in progress for practically three years, and the later results have confirmed and strengthened in every way the earlier conclusions. I shall confine my remarks to the question of recovery from pruning and dieback; an account of the other aspects of the experiment will be found in the annual report for last year which will shortly be issued.

As long ago as 1929 Dr. Gadd advanced the theory that a deficiency in the carbohydrate reserves of the bush at the time of pruning was the predisposing cause of death after pruning in the low-country, and he advocated lighter forms of pruning. Subsequent work in the field and laboratory has abundantly confirmed the hypothesis and provided, to a very large extent, a solution of the problem. If starch deficiency were the cause, it seemed obvious that a method of pruning should be adopted which would leave the bush in a condition to continue its assimilation of such material, and thus render recovery to a great extent independent of the food reserves available. Consequently, comparisons have been made of the results following on clean pruning, a cut-across, and rim-lung pruning. At Galatura at an elevation of 200 feet, rim-lung pruning resulted in a reduction of pruning mortality by no less than 87% as compared with clean pruning. That in itself is sufficiently gratifying, but it is not the only beneficial result obtained. Apart from bushes actually dying you are all aware of the large amount of dieback which follows clean pruning at this elevation. Measurements have shown that this may amount to some twelve hundred pounds of wood per acre. By the substitution of rim-lung pruning losses of this nature have been reduced by approximately fifty per cent.

As a result of these two factors and of the increased rate of recovery which follows rim-lung pruning, the yield of tea is also quite materially increased. The economic value of the work is obvious, and I am glad to see from a perusal of some of the Annual Reports of District Planters' Associations that rim-lung pruning is being widely adopted in the low-country with very beneficial results. I shall be interested to hear further comments from those of you who have personal experience in this direction.

In view of the urgency of such pruning problems, but little time has been available for a study of the general physiology of the tea bush. Information in regard to the root system of the bush, and its response to different treatment is, however, urgently required, and I hope we shall be able to give greater attention to this and similar other problems of a fundamental nature when our Physiologist returns from leave in August next.

It is impossible for me in the time at my disposal to review the work of each section and I do not propose, therefore, on this occasion to deal with the work of the Mycological and Entomological divisions. Should there be any information, however, in connection with these subjects which you may wish to have we shall only be too glad to give this.

This is, perhaps, the place, however, to say a word about the future of the Passara laboratory. The work at this laboratory was originally entirely entomological, and the Assistant Entomologist and one other assistant have been stationed there for some considerable period. In the past year, however, there has been some extension of our activities. I have already referred to the new manurial experiment which has been started there. In addition, some work on die-back and preliminary experiments in connection with the question of taints arising from sulphur dusting have been carried out there. With an enlarged programme of work the Passara laboratory facilities are no longer sufficient and proposals are now under consideration for their improvement. A decision on this point is likely to be reached during the present month, and if, as seems probable, it is decided to proceed with the scheme, the whole work at Passara will be placed on a more permanent basis and the laboratory there will, in fact, become a sub-station available not only for entomological research, but for field investigation in other subjects.

TEA MANUFACTURE

The question of tea manufacture will come up for general discussion this afternoon and it is not, therefore, necessary for me to say very much on this question at the present moment.

We have for some time been anxious to carry out a further investigation of withering conditions. Withering is still perhaps the branch of manufacture on which we have the least reliable information. There is little doubt that attention is too much concentrated on the final degree of wither obtained and too little on the means by which that figure is reached. We had during last year an offer made to us of an air conditioning plant, with which we anticipated we should be able to carry out small scale withering experiments under a wide range of temperature and humidity conditions.

This plant recently arrived in Colombo but unfortunately, owing to a mistake on the part of the suppliers, it is in its present form unsuitable for our requirements. This will necessitate a most regretable delay before the experiments can be initiated.

Arrangements have recently been made for all our experimental rollers and one of the large rollers to be converted to direct electrical drive, and these will all be equipped with automatic recording devices which will enable us to accumulate data which will, I hope, be of great assistance in interpreting the effect of different methods of rolling

We are greatly handicapped at present by the inadequacy of our small scale experimental driers and there is little doubt that these will have to be reconstructed. Proposals for doing this are now under discussion and I hope it may be possible to arrange for electrical heating of these machines.

The Chairman has referred to the necessity for accumulating funds for expenditure of this kind. An experimental factory is not a place where manufacture should proceed on routine and set lines. Comparative trials of different types of plant should be carried out, but such work would necessarily demand expenditure on a large scale which we have not yet been in a position to afford. Till we can meet such expenditure, however, we shall, in my opinion, be carrying out a most important side of our work in a very inadequate manner.

I think, perhaps, firms manufacturing tea machinery could assist us in this direction. Such data as we accumulate in regard to the various processes of manufacture are freely at their disposal, and I think some co-operation in the matter of trying out new ideas would be of mutual assistance and of ultimate benefit to the industry as a whole.

Development in plant and factory design generally, seems to me to be on rather stereotyped lines A comment I frequently hear from outside visitors about Ceylon factories is that they all seem to be of a type design and exhibit few differences of a fundamental nature. There is some ground for this criticism, and I do not think

it is a state of affairs which tends to rapid progress in design. In the last five years, for example, there has on the whole been little advance in labour-saving contrivances, and it will, I think, be agreed there is still far too much handling of tea leaf which is undesirable both on hygienic grounds and for its effects on the appearances of the finished tea. In Java there would appear to be considerably more individuality in factory design, and while I am not suggesting that their factories are, on the average, better than those in Ceylon, the comparative data obtained from factories working on very different methods should be of great value in suggesting the correct lines of advance.

CO-OPERATION IN RESEARCH

The mention of Java brings me to the question of co-operation in research. It has on more than one occasion been suggested that some centralisation of tea research might be advantageous and economical. The matter, in fact, has been discussed during the past year. I do not consider myself that such centralisation is feasible. We have only to remind ourselves that, even in a relatively small area such as Ceylon, we have found it necessary to replicate experiments at different elevations, to realise that results obtained in North India for example cannot necessarily be expected to apply to Ceylon and *vice versa*.

Co-operation between research stations is, however, desirable and a pooling of experimental experience. A mere exchange of research programme is of but little use; what is required is closer personal contact between the staffs of the respective Institutes. Some steps to achieve this have recently been taken. Mr. Forbes and I are proceeding to Java next month when we hope to have every opportunity to study their research organisations, and I am very glad to say that we shall be accompanied on this tour by Mr. Carpenter, the Director of the Tocklai Experimental Station. Arrangements have also been made for Mr. Eden to visit Tocklai later in this year and we hope to see his opposite member, Mr. Cooper, at St. Coombs in two or three months' time.

I think the exchange of ideas thus rendered possible will be stimulating to all concerned and I hope it may be feasible in the future to arrange further visits of this kind.

DISCUSSION.

Mr. A. C. D. Bagot said Dr. Norris had indicated that the cost of manufacturing compost in Ceylon was likely to be higher than at Indore. He would like to know whether large-scale experiments were being carried out on the estate referred to, and also if the value of the compost when applied to tea would be examined.

Dr. Norris said that it was likely the scale of manufacture would be increased. The question of investigating the effect of applications of compost had not been lost sight of, and he hoped to be able to arrange for such tests to be carried out.

Mr. P. A. Keiller asked Dr. Norris if any further information was available on the important subject of Witches' Broom.

Dr. Norris in reply said the position was not very encouraging as nothing of a very definite nature had yet been discovered. He would ask Dr. Gadd to summarise the present position.

Dr. Cadd said that everything that had so far been tried in connection with Witches Broom had given negative results. Recently, however, one new fact had emerged, namely that Witches' Broom bushes exhibited an extreme paucity of feeding roots. There seemed no obvious reason why a bush even though sick and weak, should not have a considerable amount of fine feeding roots. He had examined microscopically feeding roots removed from Witches' Broom bushes and had observed a dying off of certain cells inside the roots which was not found in normal roots. Exactly what this signified he was not yet prepared to say. There might possibly be some toxic factor in the soil which had an adverse effect on the roots, but this was pure hypothesis. In conclusion he said the subject of Witches' Broom was not being lost sight of, and hope had not been abandoned of obtaining some understanding of its causation.

Mr. Huntley Wilkinson asked if it would not be desirable to have a survey made of the incidence of Witches' Broom in order that figures might be obtained to show how far this was increasing.

Dr. Norris said this would be very difficult to carry out, and he very much doubted if reliable figures would be obtained. In the first place it would be necessary to define exactly what Witches' Broom was. Many specimens were sent into the laboratory as Witches' Broom which were not really so.

Mr. L. A. Wright said the Director had summarised the results of rim-lung pruning in the low-country and asked if he would say what conclusions had been reacted in regard to pruning up-country.

Dr. Norris in reply stated that it would be difficult in the time available to give full details of these experiments. An account had recently been given in a lecture before the Dimbula P.A. which had been published in *The Tea Quarterly* (1934, Vol. VII, pages 75-82). It was not suggested that rim-lung pruning should be adopted at high elevations.

The Chairman thanked Dr. Norris for his paper, and then called upon Dr. Gadd to open the discussion on 'Drought conditions in relation to tea culture.'

DROUGHT CONDITIONS IN RELATION TO TEA CULTURE.

I.—WATER AND THE PLANT.

C. H. GADD.

Of all the substances essential for plant life, water occupies a pre-eminent position. It constitutes a very large part of the fresh weight of plants; it is the medium by which all substances enter into the body of the plant, and it forms the means of transport by which food materials and foods are transported from one region to another. Yet the bulk of the water is not a permanent constituent of the plant — it comes and goes, entering by the roots and emerging as vapour from the leaves. It is part of the environment which permeates the whole plant, yet in this water take place the complex chemical and physical processes which we call life.

In many of the tea districts of Ceylon our problem has been, not the conservation of this very important liquid but the ridding of the soil of an excess of it without losing an undue proportion of our hillsides. Agriculturists in general are reputed to blame the weather, and it is not unusual to attribute failure to harvest an estimated tea crop to adverse climatic conditions. The drought of last year, however, was of a severity unprecedented in the experience of even our oldest planters and it brought in its train, particularly on the Eastern side, problems and experiences not usually encountered in tea culture in Ceylon. These problems cannot be put aside as having no bearing on normal practice.

At the end of last year, Mr. Eden and I were enabled to visit a number of estates in the Balangoda district where the effects of the drought were most severe. What we saw provided plenty of food for thought. Why, for instance, were small-holdings much less affected than adjacent, better-cultivated estates ? Those of you who have worked in the stricken areas have seen far more of the effects of drought than we could in the limited time at our disposal, and no doubt have many such problems requiring solution. The best method of solving them is to pool our observations and conclusions

at a conference such as this. For that reason the subject "drought" has been included in our agenda today. As much that will be said will have a direct bearing on normal estate practice, it is hoped that the subject will not be without interest to those who were more fortunate and did not see large numbers of their tea bushes die for lack of water.

It is my privilege to open this discussion and I shall confine my remarks mainly to the water relationships of the plant. Mr. Eden will follow on the soil aspect of the problem. That division of the subject, however, is somewhat artificial, as obviously our respective subjects are not watertight, plant growth being very closely related to soil conditions.

We may regard a healthy, growing tea bush, for the time being, as a channel through which water is constantly flowing. It enters in liquid form by the roots and is discharged as vapour from the leaves. The amount of water got rid of in this way, although invisible, is very considerable in quality. Balls has estimated that the water given off by an Egyptian cotton crop amounts to about 50 tons per acre per day, or 3 pints per plant. An acre of tea in full leaf, I estimate from experiments at St. Coombs, will lose on a normal fine day somewhere in the region of 10 tons of water, the equivalent of 1/10th inch of rain. The corresponding figures for a rainless month are 300 tons or 3 inches of rain.

During July, August and September last year (1934) one estate in the Balangoda district recorded in all 1·96 inches or an average of 0·65 inch. per month; another recorded only 1·65 inches for the 3 months or 0·55 inch. per month. The mean monthly rainfall for the same months during the preceding five years on these estates was 3·20 and 3·04 inches, respectively. It is not surprising therefore that these estates felt the full effect of the drought in 1934.

The flow of water through the tea bush is not maintained at a uniform rate. The rate of flow depends upon the rate of discharge from the leaves, and this is controlled by external factors. The quantity within the channel (the bush itself) remains constant and this water I would term '*vital water*', as a loss of even a small

quantity of it will seriously affect the vitality of the plant. If the rate of discharge from the leaves is diminished, the rate of intake at the roots is automatically reduced. Conversely, an increased rate of discharge calls for an increased intake. If the latter is not forthcoming, some of the vital water is lost, and wilting occurs.

The discharge of water as vapour from the leaves is known to botanists as the process of Transpiration, but for present purposes we may regard it simply as Evaporation to which it is closely akin. From an acquaintance with withering loft conditions, or the more homely washing day, we know that the rate of evaporation — the withering of the leaf or the drying of the clothes — is determined by such conditions as the humidity of the atmosphere. temperature, and movement of air or wind. These are the conditions which largely control the rate of loss of water from the leaves of a living bush and, consequently, the rate of flow of water through the tea bush.

If all the bushes in a field have an equal supply of water, we should expect those which lost water most rapidly to wilt first. As wind is a factor which increases the rate of evaporation, it might be expected that bushes in sheltered hollows and protected from the wind would resist drought conditions longest. But this was not observed to be the general rule. More frequently, the bushes on the hillside, exposed to sun and wind, and those well away from a sheltering windbreak were unaffected, while the bushes in the hollows and nearer the windbreaks had wilted. An explanation of this observation is not easy to find. The fact that air movement increases the rate of evaporation is beyond question, so we are forced to look for our solution below ground. I would suggest that the bushes growing in the more exposed position have either a larger root range so that they draw water from a greater volume of soil, or that they receive supplies from some obscure source. The question of root range I will deal with later, but the discussion of obscure water supplies I must leave to Mr. Eden.

Another factor, and a most important one, which materially affects the amount of water lost by evaporation, is the area of the evaporating surface. The larger the area, the greater amount of

water will be lost in a given time. For that reason, the dhoby spreads wide his sheets, and flush is spread thinly on the withering tats. The evaporating surface of the tea bush is its leaf surface; consequently, the more leaves the bush has, the larger the evaporating surface, and the greater is its discharge of water vapour.

It is pleasant to find that at least in this case observation supports theory. Speaking generally, the bushes which were oldest from pruning suffered most. Three-year-old fields suffered more than two-year-old areas and so on; the fields to suffer least were those recently pruned. For the same reason, viz. the larger evaporating surface high-yielding bushes suffered more than low-yielders — other conditions being equal. Undoubtedly the fields to suffer least were those recently pruned.

Here then is an apparently sound reason in support of dry weather pruning. That is true, if the object of pruning in dry weather is to enable the bushes to withstand drought conditions. On more than one occasion at these conferences, the pruning of tea has been fully discussed and the question of dry weather pruning has been referred to. At such times I have based my arguments on physiological grounds against dry weather pruning. I am still of of the opinion that in normal times, where severe drought does not enter into consideration, and when the recovery from the operation is the chief criterion, dry weather is not the best time to prune. But at the time when severe drought is experienced, pruning probably affords the best means of enabling the bushes to survive the shortage of water.

At such times, the pruning should be done before the bushes show visible signs of wilting, and the prunings should be left on the ground as a mulch. Pruning against drought is merely a method of rationing the water supply in the soil, the bush being forced to draw smaller supplies owing to the reduction of its evaporating surface. To be effective, rationing must be started before the supplies are exhausted. If the pruning is delayed until wilting has started, the operation may be too late. The first drooping of the leaves is indicative that the loss is exceeding the supply. That loss

is made from the vital water of the bush, and it continues so long as the leaves remain attached. There is no system of water storage in the tea bush, and the loss of vital water results in the death of the small roots and stems. For this reason I consider that pruning after the leaves have dried is too late.

In the Uda-Pussellawa district I have seen bushes stripped of their leaves at the first sign of wilt, but before they have begun to dry out. The recovery of these bushes was extraordinary. New leaves were formed along the whole length of the stems even to the tip. There was practically no dieback such as is to be seen on normal, drought-affected bushes. Stripping then is very effective if it is done at the first sign of wilting and before there is any very serious loss of the vital water of the bush. The removal of leaves by stripping or pruning affords the best means I know of, of enabling the bush to survive during the severe drought conditions.

Leaving now the exit end of our water channel we will briefly consider conditions at the intake — the roots. The water is absorbed by the surface of the roots particularly in that region immediately behind the growing tip. Here again the question of surface area is of major importance. The large woody roots are of little importance from the point of view of water absorption. Their function is mainly that of anchorage; they also form the channel through which the water is passed to the stems, and they form a frame from which the more important finer roots are suspended. These fine roots, or feeding roots as they are often termed, have a very large surface area relative to their volume, and it is this large absorbing surface that renders them so important.

A wet soil can supply water to the absorbing surface of the root system at a rapid pace, in fact, faster than the root can absorb it. But as the soil dries out, the films of water round the soil particles become thinner, the resistance to capillary movement increases and the delivery of water to the absorbing surface becomes slower until at last the soil refuses to part with any more of its water. The intake of a plant's water system, however, is not stationary, as by growth the roots penetrate into new soil regions where the water

content and water supplying power has been less depleted. Low water content of the soil, within certain limits, stimulates root development which results in an increased absorbing surface, but when the soil is very dry, root development is greatly retarded and even ceases.

The ability of a plant to withstand drought depends to a large extent upon the distribution of its root system within the soil. The first bushes to be affected by drought are those growing on a thin soil overlying slab rock, as their root systems are near the surface and the volume of soil to be explored is limited. A similar effect may be produced where the bushes are growing near water. If the subsoil is water-logged and thus unaerated, deeper roots will not develop and the main roots are consequently very superficially placed. A lowering of the water table during drought, particularly if the soil is coarse, renders these shallow rooted plants liable to water shortage. Thus bushes growing on sites which are normally wet may show signs of drought-effect quite early.

In actual fact our knowledge of the root system of tea is very limited, largely owing to the difficulties of research. We know that a large mass of fine feeding roots are to be found in the upper nine inches of the soil, but we know little about the number and distribution of the more deeply situated roots. It is a common experience when digging out bushes attacked by the *Poria* root disease, to find that although there is no visible above-ground symptom, a great part of the root system is dead. That means that under normal climatic conditions, an infected bush can carry on with only a small fraction of its normal root system. Infected bushes appear to die suddenly, and when that happens the majority of the larger roots are in a much rotted condition. I estimate that in many cases death does not occur for at least a year after first infection. During that time the extent of the root system is gradually being diminished owing to the progress of the disease. During drought, the shortage of water in the soil, together with the reduced means of obtaining it as a consequence of much of the root system being dead, causes the early death of *Poria* infected bushes. That, I think, explains the larger number of *Poria* deaths which occur during dry seasons. It is not that dry conditions

favour the disease but that they add yet another handicap to the bush. From these observations I suggest that under normal conditions the damage to the root system of the tea bush, brought about by normal cultural operations, is of negligible importance, whereas similar injury in the time of drought may have a marked detrimental effect.

Our knowledge of the root system of plants is derived largely from the work carried out on other crop plants, particularly those whose root systems are more easily excavated in detail. This work shows that root systems are much influenced by the nature of the soil, its cultivation and drainage and by root competition.

It must not be assumed that because two species of plants are grown in the same soil their roots are necessarily in severe competition. Much will depend upon the types of the root systems and the regions of soil they explore. Competition in some cases may result in more extensive root systems, which penetrate to deeper levels. I have seen young tea, thickly interplanted with Grevilleas which survived the drought when adjacent mature tea, without the heavy stand of Grevilleas, was affected. From appearance alone it seemed that the young tea plus the Grevilleas were making heavier demands for soil moisture than was the mature tea. In the Welimada district, which normally has a long dry season, tea is frequently grown with a heavy cover of Grevillea without detriment to the tea's water requirements. One can only conclude, in the absence of evidence to the contrary, that whatever competition exists between tea and Grevilleas forces root development of both plants to lower levels, to their mutual advantage in times of drought.

From this brief survey of the water relationships of the tea bush it will be evident that so far as immediate treatment of the bush is concerned the reduction of leaf area affords the best means of minimising the effects of unusual, severe drought. More attractive is the thought that it may be possible to encourage the development of a root system, such that it fully occupies the soil to an adequate depth and throughout a radius sufficient to secure water and nutrients

at all times. That is an ideal. The practical standard to which we are forced to conform is the production of crop of maximum quantity and quality. Possibly, it will be found that in general practice something of the ideal will have to be sacrificed for the economic standard, and that, at best, a compromise has to be achieved.

The plant's search for water cannot be disassociated from its search for food. Where the food is, there also will the roots be found. Root development, therefore, is much influenced by cultural practices, but on that subject I must give way to Mr. Eden.

II.—THE SOIL AS A WATER RESERVOIR

T. EDEN.

Dr Gadd has spoken to you of the general mechanism of transpiration in the plant, and of the way in which this may be checked. In so doing he has indicated how it is sometimes possible to prevent the worst features of drought. It does not inevitably follow that even with these precautions deaths and dieback will be completely prevented, because the balance between transpiration and soil moisture supplies may still be unfavourable. My province is to describe to you briefly how water is distributed in the soil, and to consider what can be done to conserve it in the soil during drought periods.

The soil may be roughly likened to a sponge. You may soak a sponge in water and then remove it, when a certain amount of water will just drip off by gravitational force. Eventually the sponge will cease to drip, and will contain in its pores, water which will only be released when the forces acting against it are great enough to overcome those that are holding it in close association. As a matter of common experience we can squeeze water out of the sponge. Finally, we are left with an apparently dry sponge, but if we placed it in an oven, it would be possible to dry it out still further. In some such manner we can visualize the soil-water held by the porous soil structure. When saturated, a mass of soil will drip and lose gravitational

water; thereafter, capillary water is held by the soil pores of various sizes, and if water is still lost by evaporation, we arrive at a stage of apparently dry soil which, however, if baked in an oven, still loses hygroscopic water.

The conditions under which plants thrive lie between the two extremes just mentioned. A water-logged soil is of no use except in special cases. At ordinary ranges of soil-moisture the plant can exert sufficient pull on the moisture to gain adequate supplies, but the last remaining traces are so firmly held that they are not available to living vegetation.

Though it is convenient to classify soil-water thus, there are no sharply defined divisions between these three states. The essential picture I wish to draw is that of water held by certain forces, some of which the plant or direct evaporation can easily overcome, and some of which offer greater resistance, so that as the quantity of water diminishes, the forces required to make that water move are correspondingly increased. The provision of an adequate supply becomes a question of how large the immediate supplies are, how hard the root pull is, and how easily and rapidly water can move from one portion of the soil to another to replace supplies utilised by the plant.

In periods of drought we are mainly concerned with movement from lower to higher levels, and it is, I imagine, a common, and one may say natural impression that, blessed as we are normally with a relatively high rainfall, there should be adequate supplies in the sub-soil to draw on when the drought pinches. In this respect I must warn you definitely that experimental evidence provides very little support for such cheerful optimism. Once moisture has receded into the sub-soil it rarely comes back again sufficiently quickly to be a factor in plant growth. In times past, a great deal has been made of the capillary theory of water distribution and supply. It has been supposed that this capillary force will rapidly draw up water from the water table over large distances, whereas actually, the capillary forces are effective only for a few feet above the water table.[1] The best authenticated estimate of the distance is no greater than six feet,[2]

However unpalatable it may sound, on the average Ceylon tea estate with its irregular contours, this fact disposes completely of that attractive speculation about capillary water. The result is that the plant has either to go in search of water at depths where loss has been less severe, or has to depend upon the very slow efforts a soil makes to distribute its water content evenly within its mass. The normal procedure on our soils is for the top layer to dry out, and for this dry layer to extend downwards until the resistance to evaporation that this dry layer provides, minimises further loss. Unfortunately, the roots of tea are ordinarily restricted to this extending dry layer, and the tale of consequent disaster is plainly written this year in the districts of Balangoda and Uva.

What then can be done, particularly by cultivation processes, to minimise inevitable losses? Is it advisable to cultivate in a drought with a view to forming a soil mulch? The answer is definitely no. The aforetime much-desired mulch is valueless as a means of stopping loss of capillary-raised water, since the latter is non-existent at our distances from the water table. If it could be produced satisfactorily, it would form a non-heat conducting layer to protect lower layers from evaporation of such residual supplies as are present, but except in a minority of light soils nothing worthy of the name of mulch is producible. As you will see tomorrow, our soils are definitely clay soils containing in some cases 40 to 50 per cent. of fine clay particles, difficult to cultivate and bring into a state of fine tilth. The only effect of forking these soils in dry weather is to increase considerably the surface exposed to evaporation.

On the other hand, if a non-conducting mulch can be otherwise procured, some advantage will be gained. Such a mulch is provided by Grevillea droppings, and where these form a good carpet, the soil temperature is noticeably lowered and the surface soil protected. With the cognate question of competition between tea and shade trees I will deal later.

Passing from cultivation in the drought period to cultivation in general, the lesson emphasised by the last few months is that of deep cultivation. In the main, our soils cake and form a cap readily.

Cultivation ensures that the surface layer is in a suitable condition to receive, with a minimum of run-off, any rain that occurs. But there is a further effect: the roots of tea do no more vertical exploration than is required to meet their needs, and the bulk of the adventitious feeding roots are concentrated in the cultivated and manured layer. A policy of shallow forking, particularly a mere scraping in of manures, encourages a shallow feeding root surface which is easily affected by drought. The same conclusion has recently been arrived at in an exhaustive root survey of coffee.

One of the most striking sights our drought tour provided was that of manured and forked tea suffering badly, whilst adjoining tea, giving an equal or greater yield per acre, which had received no cultivation or manure since planting, escaped almost entirely. There was in this case a difference in age of the two plantations; one was five years old, the other fifteen. Whether age, or cultivation, or, as seems likely both were responsible for differences in root range, the argument for deep cultivation, when cultivation is resorted to, seems irresistible. Nobody I hope will infer that because of the localisation of roots by manuring and cultivation, these processes are to be dropped. It would be ludicrous to forego maintenance of crop for forty-nine years for the sake of possible immunity from deaths of tea bushes in the fiftieth.

An additional help in conserving moisture is suitable drainage. Many districts where drains are needed to discharge surplus water at one time of the year, would be only too glad to trap scattered moderate falls later on when drought threatens. Reverse slope drains offer advantages in both seasons. They are superior to silt-pits because of their greater capacity and because their percolation path is within the range of the feeding roots. A silt-pit at the bottom of an existing drain distributes its contents less evenly and less advantageously. The situations in which any attempt to waylay water would be detrimental are not nearly so extensive as may be imagined, and this compromise between lock-and-spill and open drains deserves a more extended trial both on this and other grounds.

On the question of competition between tea and shade trees a long view must be taken. We must credit their virtues over long periods against possible disadvantages occasionally. We have seen areas of tea under shade where drought casualties have been severe. These have generally been in hollows. Close by, with equally dense shade no such effect was visible. More curious still, on exposed and rocky slopes and towards the tops of ridges, particularly facing the prevailing wind, drought effects have been very little in evidence.

From the industry's point of view, it is satisfactory that severe droughts are infrequent, but from the point of view of scientific investigation it is a handicap. The most I can do is to invite you to relate your own experiences in the discussion period that will follow, meantime suggesting possible causes for this remarkable state of affairs.

Some exceedingly interesting work done in South of France [3] and at Poona, India, [4] has shown that there are important secondary sources of soil-moisture besides rain and dew. Experiments at these two centres have demonstrated that water can be absorbed from air on soil or rocky surfaces when the temperature of the air is much higher than the dew point, *i.e.*, under conditions which preclude dew formation. During a period of three months' dry weather at Montpelier, the average deposit of water in the top layers of soil reached a daily figure equivalent to a quarter-of-an-inch of precipitation. Assuming that this quantity was evenly distributed over a depth of nine inches, it would account for a difference of about 2·25 per cent. in moisture content.

All this may sound very surprising, but it is not only an experimental fact, but one of which practical use is made in vine and olive culture. In certain countries, olives are protected by building little walls of dry stone round them, and it is common knowledge that rocky slopes in vineyards suffer drought less than the average. In this country every one must have noticed the tenacious hold which lichens have on bare stone and boulder well removed from any absorbent soil, and yet they survive the keenest drought. On these lines we have a possible explanation of the behaviour of exposed and rocky

ridges which, as was previously mentioned, seemed at first sight to be behaving in an anomalous way.

We may sum up the soil aspect of this discussion on drought in tea in these words:—

Under our conditions of soil texture and ground contour, we have little to hope for from the tapping of sub-soil reserves, or from the protective influence of a soil mulch. We must depend largely on root exploration aided by deep cultivation, and stimulated by the competitive activities of suitable associated shade trees. We shall have to leave in the balance the question as to whether in specially severe circumstances the latter effect is overshadowed by the demands of the shade trees themselves. Cultivation in the dry period is to be avoided as leading to increased direct evaporation and root injury at a specially critical time, but there is everything to be said for having a reasonable tilth formed before the dry period sets in and persisting through that period. Whatever secondary sources of moisture are available can only be deposited in a well-aerated soil. Their effect is evanescent, and the moisture will have no time to diffuse any distance before the drying effect of the sun reasserts itself. Consequently, such secondary absorption water must be deposited in close contact with the roots for immediate use. There is no universal and unfailing panacea for averting drought, but attention to these points will minimise its effects, and, according to the severity of its incidence, may sometimes provide complete immunity.

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DISCUSSION.

Mr. E. E. Megget in opening the discussion, said that he had discussed this subject in its various aspects with superintendents of estates in the Balangoda area, which had experienced exceptional conditions. The superintendent of one of the high-yielding estates, which had been badly affected, had intended to be present at that conference, and his views would have been of considerable interest. Unfortunately, he was laid up with malaria and could not attend.

The conditions in the Balangoda area were exceptional, as it was situated on the border line between the wet and dry zones. If a line were drawn running roughly north and south through Balangoda town, on the west of it they got south-west rains, which from an average of 7 estates amounted to 7·4 inches during the third S.W. Monsoon quarter last year, as against 20·3 inches in 1933. To the east of that line, conditions were more like those which prevailed in Uva. From an average of 5 properties on that side of the line, the rainfall for the same quarter amounted to only 1·52 inches, as against 12·39 inches for 1933 and a mean of 10·2 inches for the previous three years.

Other exceptional conditions were the failure of the May rains. The records of one estate showed that the rainfall figures for the second and third quarters of 1934 were the lowest recorded during the last ten years. The rainfall of the fourth quarter, which was the time when the heaviest rains were recorded, only exceeded the lowest record by 0·14 of an inch. The prolongation of the period of short rainfalls was, therefore, a prominent feature.

He stated that it would take a wiser man than he to puzzle out the why and wherefore of the varied effects of these exceptional conditions. Impoverished, uncultivated tea appeared to have suffered least while the highly cultivated, highly-yielding areas had been very markedly affected.

In the case of one outstanding property, it was estimated that 7½ per cent. of the bushes were lost in spite of the fact that only half the place was affected to any appreciable extent. One field, as fine a sheet of tea and lie of land as one would wish to see, lost 25 per cent. with a further 10 per cent. of bushes distorted. In that particular case, the field was forked and a heavy crop of green matter incorporated in June.

A striking feature was that although the bushes were now looking healthy and vigorous, they were not giving crop. As an example, he mentioned a high-yielding estate which, though the yield usually jumped after a drought to 125 pounds per month, did not then exceed 40 pounds, and had not yet got into its stride.

Dr. Gadd and Mr. Eden during an inspection made after the drought had found it difficult to reconcile the varied conditions seen. The former had expressed the view that bushes showing no sign of life around and above the collar would not recover. It was, however, of interest to note that many such bushes had recovered and that growth had come through from well below the crown.

Hollows and sheltered fields that got the sun but were sheltered from the wind appeared to have suffered markedly more than other areas.

It seemed to him, and broadly his views were in agreement with those with whom he had discussed the matter, that conditions were sufficiently abnormal to justify the hope that they need not take them into consideration to any drastic extent in their agricultural practices. But it was worth while considering whether there was not a tendency to do too much cultivation in areas that did not get the south-west rains. Under such conditions, it was hardly possible to carry out more than one forking, whilst at the same time ensuring that the damage did not outweigh the good done. That referred particularly to work done just prior to the dry weather.

Except when a reasonable period of rainy weather could be anticipated harm might accrue from the incorporation of heavy masses of green and other organic matter, and from leaving the forked soil in the rough. When cultivation was to be done and there was reasonable expectation of drought at no distant date, it would be better to break down the sods after forking and leave a good deal of the green and other vegetable matter on the surface of the cultivated ground.

In connection with a statement made by Mr. Eden, he quoted Californian experience, where the annual rainfall was restricted to 13 inches falling within a period of three months, as an example of how, using correct cultivation, the rigours of drought could be faced without fruit crop failure.

He would not express any views regarding pruning in connection with drought, as what appeared to have been successful under such exceptional conditions seemed to run contrary to what one had assumed to be correct—that was to avoid using the knife on tea when it was feeling the strain of adverse weather conditions. As a matter of interest, however, he would add that on an estate badly affected by the drought he was shown two fields, or more correctly, two sections of one large field that were pruned in November. In one section a more liberal amount of rim-lungs was left than in the other; growth in the former was markedly backward as compared with the latter.

The value of deep cultivation, with the incorporation of organic matter to ensure the speedy formation of humus, was specially marked under the conditions experienced.

The incidence of the unusual drought contained a useful lesson, in that it brought home the importance of initiative on the part of superintendents. That, he considered to be essential if programmes were to be carried out in such a way that the best could be made of varying climatic conditions.

The exceptional drought also emphasised a point of considerable interest, in that the limitations of yield were more a matter of soil moisture than of plant food. Leaving aside economics, it was within their power to incorporate in the soil plant food adequate for any requirement, but it was not within their power to ensure an adequate supply of moisture to convey that foodstuff to the plant. They could of course by tillage and by increasing the amount of organic matter in the soil improve its retentiveness and so conserve moisture.

The Chairman suggested that someone from Uva might give them the benefit of their experience.

Mr. C. F. Troup said that as no one from Uva had risen in response to the Chairman's request, he would, with his permission, relate a little of his experience during the drought. The drought experienced at the far end of Uva, in Madulsima, was the most severe he had known. The only other drought which had been of equal severity he thought was that of 1922 which had been very severely felt in his district. During the early months of the year 1934) until about the middle of April, rainfall had been about normal, but in May there were about 9 inches of rain less than in May of the previous year, and by the end of that month the tea was beginning to feel the effects of the drought.

As he had been opening clearings between 1925 and 1930—on an average of about 50 acres a year and had a fair experience of drought, particularly that of 1928, he decided to try a different method of bringing the clearings through the drought. About the second week in April, somewhere about the 17th, he began the cultivation of a 56 acre field planted in 1926 putting in a fair amount of green manure together with a general mixture. He began to prune that field early in May. Cultivation was going on ahead of the pruning, but cultivation was completed before bushes were pruned. A small amount of leaf and green material only was left on the bushes. The recovery of that clearing was exceedingly slow compared with usual rate of recovery. The slow recovery he attributed to the very long and severe drought. Only 0·22 inch of rain fell during a period of 97 days beginning on June 5th. Despite this, he had lost very few bushes from the whole of that area—hardly a single bush.

On the other hand, from a clearing of 55 acres planted in 1928, about 20 months from pruning and which was carrying heavy foliage, he had lost 3,400 bushes, all over 3 years old, in addition to numerous supplies. This was the only clearing in which losses were numerous.

He agreed with Dr. Gadd that there did not appear to be a great deal of competition between the Grevillea and the tea bush. The 1928 clearing had a poorer stand of Grevilleas than other clearings, as both good Grevillea seed and plants were difficult to obtain that year. The Grevillea, especially during strong winds, lost much of its leaf, and then the competition between the Grevillea and the tea was not very great. Possibly the Grevillea also assisted the young tea roots to find a way through the soil. Whatever the explanation might be, he agreed that the effect of intergrown shade trees, such as Grevillea and Dadap, was in general beneficial. He did not think it good to trim up the lower branches of Grevilleas or to cut down Grevilleas during or just before the drought.

Proceeding to the older fields, he found that the bushes growing near slab rock and in places where there had been a good deal of water formerly, tended to wilt and go out very quickly. In this respect also his experience confirmed the views expressed by Dr. Gadd. He lost a considerable number of Dadaps in the mature area. There, Dadap shade did not appear detrimental if kept fairly light.

His estate varied in elevation from 2,600 to 5,000 feet with consequent varying climatic conditions. The force of the South-West Monsoon was felt more strongly on one side than the other. During this drought he had lost a certain amount of tea on the north-east side, but the loss had been much less than that experienced in 1922. The comparable figures were between 1,100 and 1,200 against over 7,000 in 1922; the majority of the losses occurred in the same fields both years. On the south-west side, which was the more exposed, he lost more bushes from what had previously been damp areas, from near slab rock, and from the sides of main drains where water had been held up from time to time.

He had tried, with a certain amount of success, the cutting down of bushes which had begun to wilt, but he was afraid that he had been too late to save many of them. He began stripping some bushes only late in the drought when wilting was a little too advanced to save many. In all he had lost about 11,500 bushes from the mature areas (about 1,110 acres), but considering the severity of the drought he did not think that the loss could be considered to be very great.

He had also tried watering wherever water was available. He found that it did not pay to do so except where water was readily available, but in such places it paid handsomely.

Mr. Bruce Foote enquired whether there was a marked difference between weed growth on the adjoining areas of estate-planted and small-holdings tea.

Dr. Cadd replied that no obvious differences were observed such as would account for difference in drought behaviour.

Mr. Morford said that he had occasion to prune three fields in November when normally rain was expected. The rains failed. One of these fields was entirely devoid of any form of shade and green manure; another was very thickly covered with *Crotalaria usaramoensis* and Dadaps, while the third had very heavy shade of giant Albizzias. The three fields were carefully pruned and the leaf mulched in. The field that was devoid of cover made excellent recovery. In the field which had both Dadaps and Crotalaria, the Crotalaria being mulched but the Dadaps left in foliage, recovery was extremely poor. The third field under high Albizzias also made excellent recovery.

In another field, not on his own estate, he had noticed that the tea had been pruned but the Dadaps had been left in foliage, as shade. He wished to ask Dr. Gadd whether it would not have been wiser to have lopped the Dadaps and left the tea unpruned.

Another point which had occurred to him was that a good deal of green manure had been planted during the North-East Monsoon months, and this had been left uncut during drought. His own observations indicated that wherever the green manure had been left unpruned the tea had suffered very heavily.

Both Dr. Gadd and Mr. Eden had referred to green manures in their papers, but he had not noticed any reference to cover crops.

Another field of about 40 acres with which he was acquainted had previously consisted of old rubber and tea. Two rows of tea had been planted for each row of rubber. About 7 years ago the rubber was removed, and 2 years later the land was planted with tea. There were then four rows of young tea to every two rows of old tea. The old tea had suffered very severely from Shot-hole Borer during the drought whereas the young tea had remained healthy and had apparently not suffered from the drought nearly as much as the older tea. He had found that the increase in Shot-hole Borer was simply appalling during the drought.

Mr. R. C. Coombe said that one point prominent in his mind was the absence of wind during last year's drought, and he would like to ask Dr. Gadd or Mr. Eden whether, in their opinion, some of the observed effects of the drought were not related in some way to the absence of wind. He had been in Uva for 40 years, but could not recall another year when there had been such a marked absence of wind during a drought as occurred from the middle of May to the end of September last year.

Mr. C. W. Jones said that during the last two years or so he had grown some of the largest crops of bush green manures he had seen anywhere. The total weight of green material after cutting across, amounted to as much as $2\frac{1}{2}$ tons per acre. The different types of Crotalaria varied in weight very considerably. The green material had been cut up and forked into the soil systematically during September and October. He had never seen fields so badly affected by a comparatively short period of drought as were those which

had carried these heavy crops of green manures. It pointed to the fact that heavy green manure crops intergrown with a main crop were detrimental in abnormal weather. He asked that Dr. Gadd or Mr. Eden would give their opinion on the subject.

Mr. Gordon Pyper asked Mr. Eden to tell them whether there was any similarity between the lichen he had mentioned as growing luxuriantly on rock and the lichen and moss they scraped off the tea stems at considerable expense. He thought that it might be desirable to keep the lichen if it could absorb moisture from the air.

Mr. J. P. Blackmore said that in discussion, Crotalarias had been mentioned, and he would like to have the Institute's opinion on the effect of Indigofera on soil-moisture.

Mr. P. A. Keiller said that before Dr. Gadd replied he would like to add a little information on the subject of green manures. An estate in the Balangoda district with which he was acquainted had in parts a very cabooky type of soil. When this part was planted considerable anxiety was felt regarding the ability of the plants to survive the annual drought. This field as well as the whole estate had been very heavily green manured from the start, and it was his personal opinion that it was largely due to that treatment that the field had come through each drought, including last year's particularly acute one, without damage. Had that not been done he felt certain that they would have had considerable trouble.

Mr. H. Tonks also referred to the absence of wind during the last drought on the Uva side. He said that the rainfall had not been so short as in 1922, but the effect on the bushes had been more severe. He also remarked that the drought conditions varied in the different districts, and asked speakers to state to what district their observations related, as there were three types of drought being considered now; the ordinary drought of Uva, Uda-Pussellawa, and Maturata districts; the exceptionally severe drought in 1934 in these districts; and the unusual drought in 1934 in the south-west districts; all of which had to be considered from different points of view.

Mr. John Horsfall said that one of the consequences of the absence of wind had been an abnormally high temperature. He thought that Mr. Coombe would agree with him that in a normal Uva drought, the leaves wilted and fell gradually. During this drought the leaves shrivelled and remained attached to the stems much longer.

Dr. Cadd said that he had listened with very great interest to the observations made by the various speakers. When travelling through the drought districts he found that, no sooner had he arrived at some satisfactory explanation to account for certain observations than he saw something else which threw considerable doubt on the validity of the explanation. No doubt they

had experienced much the same thing. So he did not want them to believe that this replies to the questions were necessarily the last word on the subjects.

Mr. Coombe had remarked on the absence of wind. He (Dr. Gadd) recalled that when he realised that bushes in exposed positions stood up to the drought better than those in more sheltered positions, he jumped to the conclusion that such bushes had been defoliated by the wind. On making enquiries regarding that point he was informed that although it was usual for such bushes to be stripped of their leaves, the wind on this occasion had not been of sufficient strength to defoliate them. He was, therefore, forced to find some other explanation of the survival of exposed bushes, and as he had said in his paper, he thought that the explanation would be found underground.

Associated with a decrease in wind was an increase in temperature. Temperature was a factor which normally increased the rate of loss of water from the plant, and it seemed to him that many of the observed drought effects could be attributed to the high temperature.

Mr. Megget had also made a point of the slow recovery of the bushes after wilting. That, he thought, was to be expected. Wilt could be divided into two types. First there was the type which could be called *temporary*. Temporary wilting could often be seen in the garden, when during a hot afternoon, the leaves of certain plants began to flag or droop. As soon as the evening came along, the plants began to revive. Such a wilt did not result from an absence of water in the soil, but from the inability of the roots to take up moisture fast enough to keep pace with the loss by transpiration from the leaves. In the evening, particularly at sundown, the rate of loss from the leaves decreased, with the result that the roots were able to catch up and make good the loss of water which had occurred during the wilt.

The other type of wilt was termed *permanent*. A permanent wilt resulted from lack of water in the soil. In such a case the plant did not recover when further loss of water from the leaves was prevented. Usually, the plant was covered with a vessel, so that the atmosphere could be saturated with water, and if recovery did not occur within 24 hours the wilt was classified as "permanent". It was known that the recovery from permanent wilting was very slow indeed, even though the soil was supplied with abundant water. The reason for the slow recovery was that during the wilt the plant lost so much "vital water" that the vital properties of the rootlets, or feeding roots, were affected; in fact, local death might result. The first step towards the recovery from permanent wilting was the development of new feeding roots, and that largely accounted for the delay in recovery. The wilting of tea during the drought was, of course, of the permanent type.

Mr. Megget had also remarked on the fair percentage of recoveries from the effects of drought in the Balangoda district. In the speaker's opinion, Balangoda should be congratulated on that fact. When in that district, he had examined a number of bushes for which he thought there had been no hope of recovery. At various places he had examined a large number of bushes which appeared dead. Many were alive at the collar although the whole of the aerial parts were dead. Such bushes, he thought, had some chance of recovery by the production of new shoots at ground level. But many bushes he had examined in the Balangoda district had died back for some distance along the taproot and even along the main lateral roots. He could hardly believe that bushes which had died back so far could possibly recover, though he quite realized that many apparently dead bushes in that district would make new growth from the region of the collar.

As regards the question of growing green manures during a time of drought, there could be no doubt whatever that a green crop, grown in lines between tea, made very heavy demands on the soil for water, and was then in very keen competition with the tea for that supply of water. It was obviously inadvisable to have a green crop standing at such a time, but he did not think that any observation could be made against green manures in general on that score.

Referring to Mr. Morford's question asking whether the tea or the Dadaps should be pruned, Dr. Gadd said that he realised that whatever he replied his answer was sure to be wrong, at least to someone. He had already explained that one way of reducing the effect of drought was by removing the leaf surfaces from which the water was lost. Here he would take the easy way out of his quandary and reply that both the tea and the Dadaps might have been pruned.

Mr. Megget had told them of a field in which, at pruning, more "rim lungs" had been left in one part than in another. The area with the more "lungs" was markedly backward as compared with the area where fewer "lungs" had been left. He (Dr. Gadd) thought that the pruning must have been done when there was little water left in the soil. Clean pruned bushes make very little demand on the soil for water. The bushes with more leaves made greater demands, so it was possible that these bushes with the greater number of "lungs" felt the effect of water shortage more keenly than those with fewer "lungs". Much depended, however, on the amount of water available at the time of pruning.

Mr. Pyper had asked whether the lichens Mr. Eden had referred to as growing on stones were the same as those found on tea stems. He could not say with certainty whether the lichens which often gave the stems a white-washed appearance, were of the same species as those which grew as white

or coloured patches on the surface of stones. They might be different biologically, but from a practical point of view they could be taken as identical. Those lichens which grew as thin films, closely adherent to the bark were not removed during ordinary mossing and ferning operations; in fact they could not be removed mechanically without causing some injury to the bark. Any water they absorbed was reserved for their own needs and was not passed on to the bush.

Mr. Eden in his reply recalled Mr. Megget's mention of conditions in California where fruit could be grown with a rainfall of thirteen inches falling in three months. California was one of the standard examples of conditions where the so-called dry farming could be practised with advantage. He wished to re-emphasise the fact that benefit from mulching under Californian conditions did not necessarily imply benefit under Ceylon conditions. Bearing in mind the experiments he had quoted, it was highly improbable that, except in a few situations, the Californian experiences provided an analogy that could be accepted with assurance.

Mr. Eden went on to say that Mr. Troup's experience of drought had been of particular interest to him. He had referred to that very puzzling observation that fields facing the prevailing winds suffered less than those on sheltered slopes. This fact was one of the greatest 'posers' he had encountered in his Ceylon experience, and he was not going to pretend that he had a satisfactory answer to it. Those secondary sources of moisture he had mentioned were well worth considering. It was a fact that although dew deposition was associated with relatively still air conditions, some movement of the air helped the dew formation by renewing the surface layer of air. The same sort of air movement was conducive to the absorption phenomenon he had mentioned as taking place even above dew point temperature. He could only leave it as a suggestion that the reason why exposed hillsides had on this occasion showed less damage than unexposed hillsides or areas where the soil was protected by the shade trees, was the fact that there had not been sufficient air movement on the unexposed areas to allow the maximum use of these sources of water.

Mr. Jones and Mr. Morford had raised the question of green manures, and Dr. Gadd had told them that there might be a severe demand upon soil moisture for these crops during a drought. To that reply he would only add one point, that, in the nature of things, crops like Crotalaria were more definitely exploiting the same layers of soil as tea, than was the case with shade trees. Mr. Blackmore had raised the same point with regard to Indigofera, and the speaker thought that here again benefit and harm were counter-balanced.

Mr. Jones' experience seemed to him to follow the lines he would have expected given the conditions described. Mr. Jones had a very heavy crop of bush green manure unrooted and forked in, in September and October. With the ensuing unseasonable drought, the green manure was not in a position to rot down, and consequently its effect had been to provide the soil with a large amount of air space and the drought had been let into the soil. But on balance, the contributions that green manure made in various other ways far outweighed the disadvantages that could crop up owing to such exceptional circumstances.

Mr. R. K. S. Murray said that there was one point in connection with the question of wind exposure which appeared to have been overlooked. He referred to stomata as a means of controlling transpiration. He recollected that in the days when he was supposed to be learning plant physiology, a plant was exposed to wind created by an electric fan. As the velocity of the wind increased so did the rate of transpiration. But if the fan was turned on at full speed, so causing the leaves to be violently shaken, the rate of transpiration was reduced owing to the closing of the stomata. He was not well acquainted with wind conditions in Uva but he suggested the possibility that the wind caused the leaves of bushes on exposed hill sides to agitate to such an extent that transpiration was cut down.

Dr. Gadd said that he had purposely avoided making any reference to stomata and their ability to control transpiration to some extent. He thought that, in the past, palnt physiologists had rather overstressed the importance of stomata in controlling transpiration. It was undoubtedly true that much of the water vapour left the leaf via the small pores, called stomata, but it was through these pores that a great part of exchange of gases also took place. A stoppage of transpiration by the closing of stomata also meant a stoppage of the interchange of gases between the plant and the air, and that was as vital to the plant as was water. He did not think that the phenomenon referred to by Mr. Murray would satisfactorily explain the observation made in the field.

Mr. Eden in reply to Mr. Murray, said that the transpiration through the cuticle had to be taken into account even after stomatal apertures were reduced or closed.

The Chairman before adjourning the conference thanked Dr. Gadd and Mr. Eden for their papers, and all who had taken part in the discussion.

AFTERNOON SESSION.

Chairman.—Mr. Jas. Forbes (Jnr.), Chairman of the T.R.I. Board.

DISCUSSION ON MANUFACTURE

I.—THE THEORY AND PRACTICE OF TEA DRYING

J. LAMB.

In choosing a subject on which to open the discussion on manufacture at this conference, I came to the conclusion that it would be better to concentrate upon one particular aspect, rather than to generalise on the whole process of manufacture.

The next question was where to concentrate, and my thoughts rapidly centred on the firing process, for since taking up my duties as Tea Technologist most of the difficulties I have encountered in advisory work have been connected with firing. I think I should be safe in saying that nearly all the difficulties which arise in tea manufacture are largely a matter of moisture contents at the various stages and originate from withering, but that all the consequent variations pass on to the firing stage.

Firing has to bear the brunt of all previous variations; yet in many ways it is easiest to control. It is the last stage of manufacture proper, but biological changes are still going on, and so the subsequent behaviour of made tea depends on firing.

At this stage we must fix the leaf and convert it to a stable product which will travel to all parts of the world without loss of condition.

I intend to confine myself to those machines using hot air which are employed in Ceylon almost without exception. The simplest way of following the details of the process of hot air drying is to trace the air through the drying machine from the stove to the exhaust vent.

THE STOVE

In this programme we come first, therefore, to the Stove.

The object of the stove is to transfer heat from fuel to air. The method is commonly that of pulling air through or over heated metal tubes. There is no contact between the air of the drier and gases from the furnace. The path of the air used for combustion in the furnace is from outside, through the bed of the fuel, round the tubes, into the flue, then up the chimney. This path must be kept clear by regular cleaning, and such devices as spark arresters examined for blockages. The paths of the flue gases for vertical and horizontal tubes are indicated in Plate I, Figures 2 and 3. In the case of electrical heating, the actual air of the drier passes directly over the heating elements which play the parts of both furnace and tubes.

The method of burning the fuel materially affects the efficiency of the machine.

Comparing the various fuels on the basis of cost per British Thermal Unit of heat, we get the following figures:—

10,000	British	Thermal	Units	from	liquid fuel	cost 2·07 cts.
10,000	,,	,,	,,	,,	firewood	,, from 0·34-0·63 ,,
10,000	,,	,,	,,	,,	coal	,, 1·26 ,,
10,000	,,	,,	,,	,,	coke	,, 1·30 ,,

Wood, coal, and coke are, therefore, cheaper sources of heat than oil, provided that they are burnt with equal efficiency. To achieve efficiency the fuel must be burnt completely but not too rapidly. Oil admits of comparatively easy control, but greater skill must be exercised in the burning of wood, coal and coke in order to reap the benefit of their lower cost as sources of heat. This skill is largely a matter of control of the draught through the furnace.

There are three places at which the furnace draught can be controlled:—firstly, the grate; secondly, the furnace door which is usually better closed; and thirdly, and by far the most important, the chimney damper. The firing cooly should be taught to regulate the combustion by careful use of the chimney damper, taking care to avoid excessive draught and consequent waste of heat up the chimney. Plate II, Figure I, illustrates these points and is worthy of careful consideration.

PLATE I.

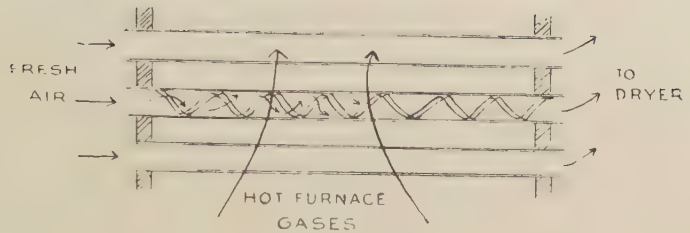


FIG 1

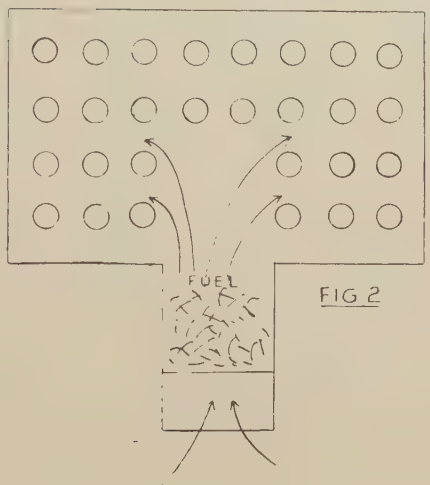


FIG 2

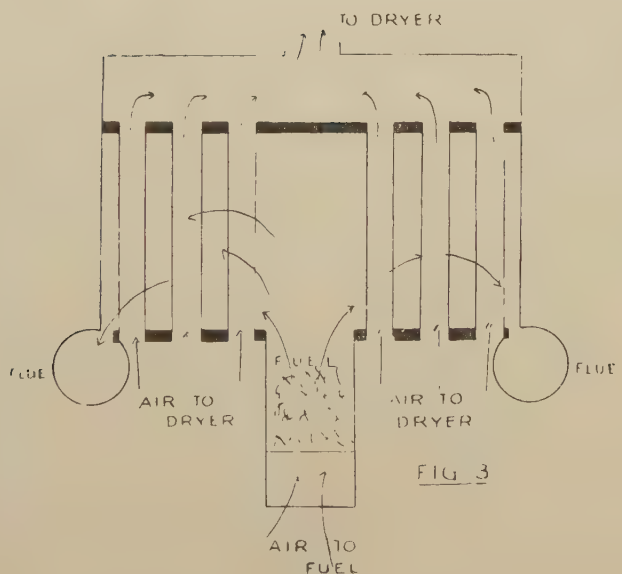
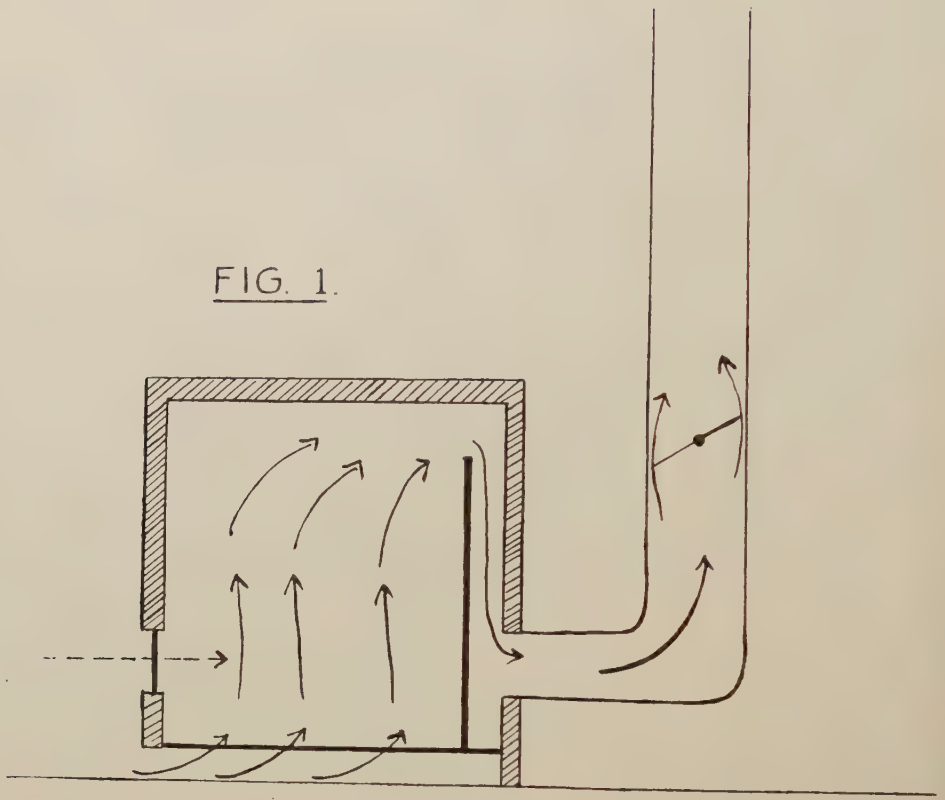
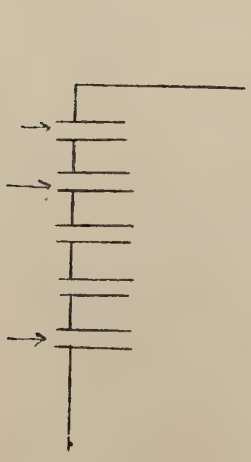


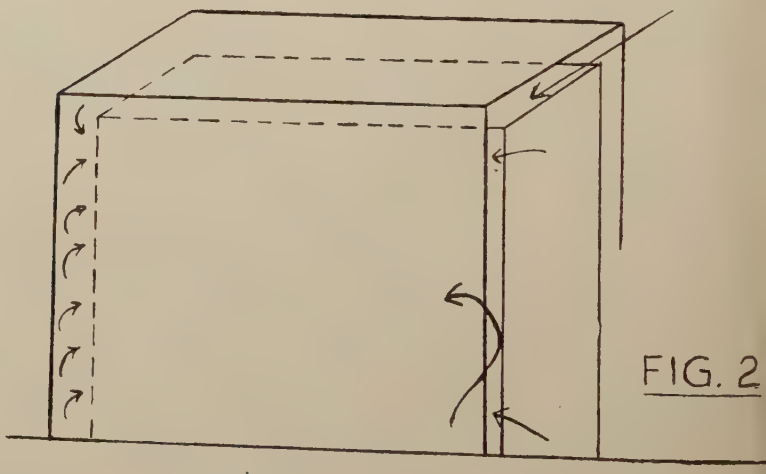
FIG 3

FIG. 1.





UNCASED



CASED

FIG. 2

The hot gases from the furnace must be evenly distributed round the tubes and as much of the heat as possible must be retained in the machine before the gases pass up the chimney. In some modern machines, where there is a large area of tubing and a rapid cooling of the flue gases, a forced draught, produced by a fan, instead of a natural draught, must be employed. This draught is still subject to regulation at the same three places.

The factor limiting heat absorption by the tubes is the presence of moisture in the flue gases. This moisture arises partly from combustion.

$$\text{Fuel} + \text{Air} = \text{Carbon dioxide} + \text{Water}$$

and partly from the fuel itself, *i.e.*, the fuel being wet. If flue gases are cooled too much, this moisture will condense out. The condensation of moisture is commonly observed when the stove is first lit up and in places where the gases do not circulate freely.

Now let us consider the actual drying air which is to be heated by the furnace gases. The larger the volume of air, compared with the surface area of the tubing it is passing through, the more efficient the heating. The modern tendency is to achieve economy by these means. Thorough contact between the air and tubes may be helped by spiral strips of metal as shown in Plate I, Figure 1, for types where the air passes through the inside of the tubes. The heat radiated by the stove may be conserved by casing the stove and forcing air drawn to the tubes to pass over the surface of the stove as shown in Plate II, Figure 2. The tubes nearer the fire box are naturally in a hotter position than the tubes on the outer parts of the stove. More air should be forced through the inner and hotter tubes therefore, and this is usually done by baffling the cooler tubes.

The cold air inlet which short circuits the tubes should only be used in extreme cases of emergency as this starves the tubes of air and may lead to their burning. The inlet should be carefully watched for leaks and may quite well be tied up with a piece of twisted wire. Many machines are fitted with a bulking chamber into which the air passes from the stove for mixing before passing on.

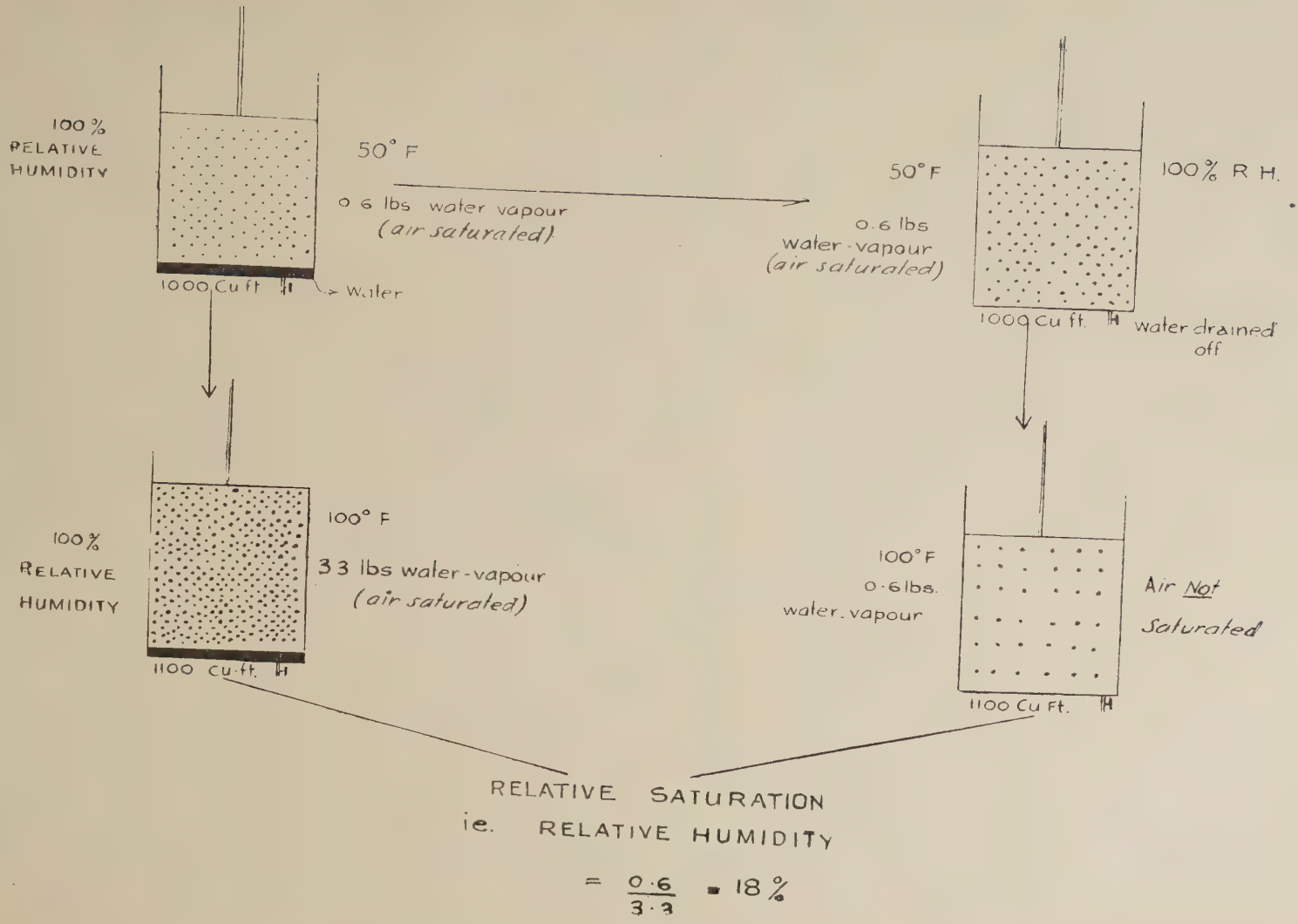
The efficiency of a drying machine is largely affected by those details of design and operation of the stove which we have been considering. That this efficiency can be very strikingly demonstrated as a matter of rupees is shown from two firing tests which I have carried out in Ceylon. In one case 9·75 pounds of fuel were required to evaporate one pound of water, whereas only 0·9 pounds were used in a modern machine. In this calculation, correction has been made for moisture content and calorific values of the fuel, which in both cases was firewood. The machine using ten times more fuel than it should was situated on an estate, extremely well off for firewood, and which valued good fuel as low as Rs. 1·50 per yard at the factory. With an average of 300 pounds of made tea a day there was an opportunity for saving Rs. 1,750 a year, even with good firewood available at the low cost of Rs. 1·50 per yard, by the use of a more efficient machine.

We have seen that the object of stove design is to transfer, as efficiently as possible, heat which is latent in the fuel to the stream of fresh air drawn from outside the factory. The next step is to consider the changes which have taken place in that air before it comes into contact with the dhools.

A simple way of visualising the change which takes place in heated air is expressed diagrammatically in Plate III. We see a box with a movable plunger. The box contains air and there is a layer of water in the bottom of the box. There is also a tap for running off this water. The ultimate particles or molecules of water are in constant vibration, and some are thrown into the air as water vapour. This rate of vibration increases with temperature until it becomes so violent that the water completely vaporizes. This happens at 212°F. at which temperature the water changes to steam.

In the first diagram some of the particles of water from the surface are shown to have flown off into the air. If the system is allowed to reach an equilibrium at 50°F., 1,000 cubic feet of the air will contain 0·6 pound of water vapour. That is the saturation point, or 100 per cent. relative humidity.

PLATE III.

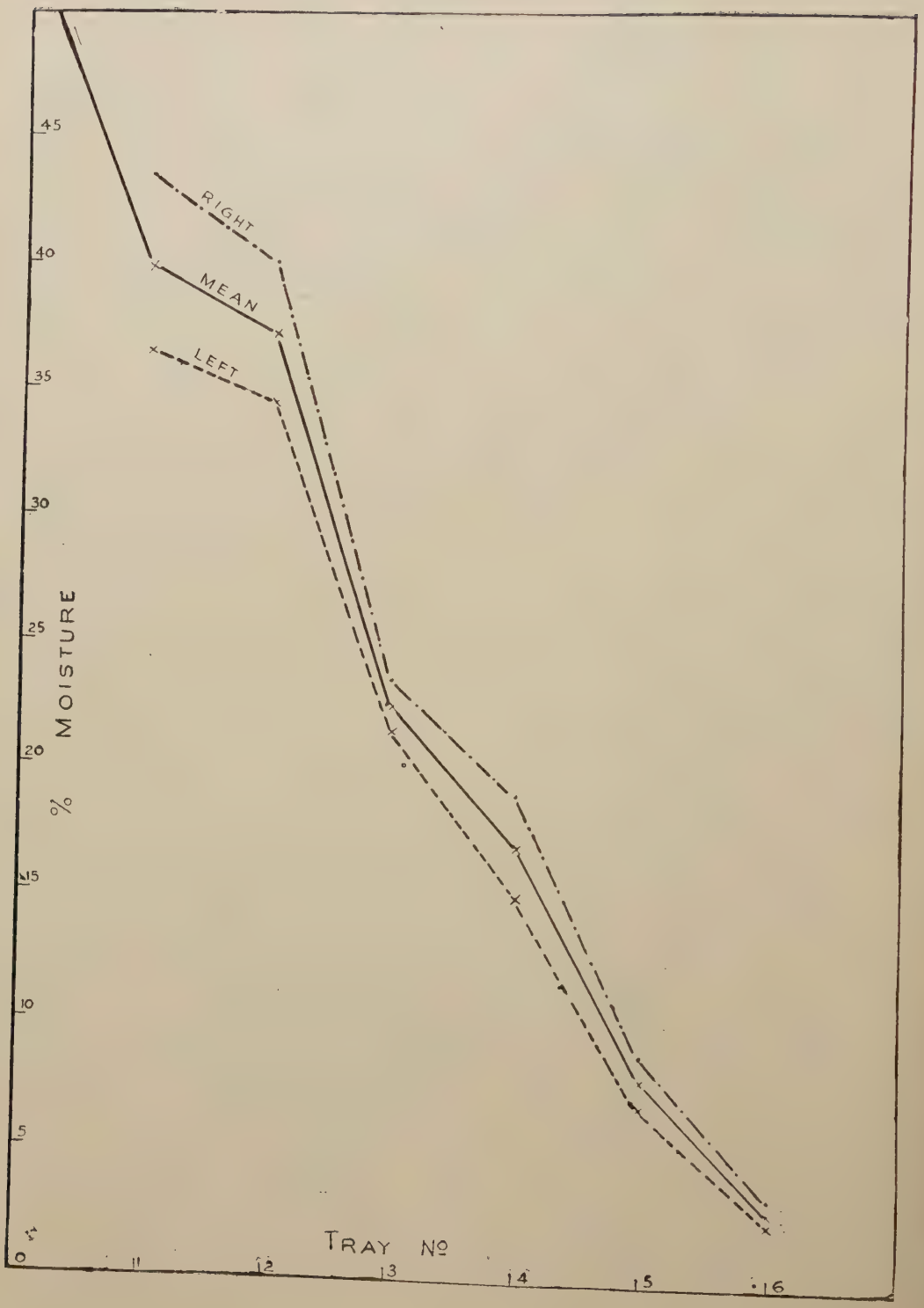


RELATIVE SATURATION

ie. RELATIVE HUMIDITY

$$= \frac{0.6}{3.3} = 18\%$$

PLATE IV


45
40
35
30
25
20
15
10
5
0
% MOISTURE
RIGHT
MEAN
LEFT
11
12
13
14
15
16
TRAY No

Now if this system be heated to 100°F. and allowed to attain equilibrium, more energy in the form of heat is supplied to the water molecules and more pass into the air as vapour. In addition, the 1,000 cubic feet of air has expanded on warming to 1,100 cubic feet. Altogether this space contains 3·3 pounds of water vapour, a very big increase for 50°F. rise in temperature.

Now suppose that before heating the excess water had been drained off by means of the tap. On heating to 100°F. the space still only contains 0·6 pound of water vapour, as there is no more water to change to vapour. The air is therefore not saturated but only $\frac{6}{33}$ or $\frac{2}{11}$ or 18 per cent. saturated. This same air therefore still has a large capacity for taking up water vapour. If the air is heated to 200°F., the capacity for taking up water vapour is further increased.

We can regard the air heated in the stove as successive 1,000 cubic feet portions of air heated up in the absence of free water. The increased drying power of the hot air lasts only so long as the temperature is maintained. If the temperature falls, the drying power falls. The mere fact that damp air is heated does not remove water from the air; the air is only relatively dry so long as it is hot.

Hot air passing over wet tea leaf tends to become saturated with moisture. Heat is necessary for changing the water in the leaf to vapour, and this heat must come from the hot air itself. Consequently the temperature of the hot air falls, and the more moisture it absorbs the lower the temperature falls. Thus the exhaust temperature gives an index of the amount of evaporating work done by the air. After the air has passed over the wet dhools and its temperature has fallen as low as 120°F. as much work as is advisable has been obtained from the air.

Heat supplied to the tea leaf can either be used to increase its temperature or to evaporate its moisture, and while the latter process is taking place, the former is at a minimum. It is thus easy to see that the leaf cannot rise to the temperature of the air so long as evaporation is taking place and the energy of the hot air is being used almost exclusively for the latter purpose. The higher the rate

of evaporation the bigger the temperature difference therefore between leaf and air. For this reason it is sound practice to lead the air over the driest leaf first, for this enables the leaf temperature to be raised before discharge as made tea. Furthermore, the air approaching the exhaust does not produce such a high rate of evaporation in the dampest leaf, *i.e.*, that fed to the machine, which means that more heat is available for raising the leaf temperature.

We shall see the importance of raising the leaf temperature in the next section.

THE DRYER

The hot air now enters the dryer, where as we have seen, it comes into contact first with the driest leaf which is nearing discharge and finally, before being exhausted, with the dampest or newly fed dhool.

One advantage of this system is, as we have already seen, that the average leaf temperature is raised higher than it would be if the flow was reversed, that is to say if the hot air passed over the fresh dhool first. This system has other advantages also; the moisture in the leaf is increasingly difficult to evaporate as the leaf becomes drier and drier, so the air with the greatest drying power is employed for the drier leaf. Conversely, the moisture in the damper leaf being more readily removed, the almost exhausted air with diminished drying power has a better chance of doing useful work.

There are two main types of drying chamber:—

(a). The suction type in which the hot air is sucked through the drying chamber by means of a suction fan.

(b). The pressure type in which the hot air is forced through the dryer.

In both types of machine one of three different tray mechanisms may be employed:—

1. Moving trays including the dessicator.
2. Tilting tray.
3. Endless chain.

Pressure machines bulk the hot air and give a more even distribution. When sucked through the drying chamber, the hot air tends to flow in streams and if one side of the stove is getting more air than the other, hotter air may be drawn over one side of the trays than the other, resulting in uneven drying.

The fan of the pressure machine sucks the air through the stove but bulks it before forcing it through the drying chamber. It also imparts a turbulence to the air stream which, if it continues in the drying chamber, effects further bulking within the chamber and results in more even drying.

The distribution of air in the dryer is arranged by means of fixed baffles which are most important features since uneven air distribution may cause uneven drying.

From the principles discussed we can now formulate a scheme for operating a dryer.

1. Set the fan speed and tray speed, where adjustable, to the maker's recommendation. This may have to be altered if results are not satisfactory, but we shall see the reason for any such alteration as we proceed.

2. Maintain a steady inlet temperature not below 185-190°, using the chimney damper to control the furnace. If difficulty is found in keeping the inlet temperature up, and the furnace is in good order, search for leaks of cold air. The stove is under suction in all machines and so leaks will be inwards. Stove doors and cold air inlets are often found responsible for leaks. Such leaks should always be guarded against as they mean loss of efficiency and starve the tubes of air.

If all else fails the fan speed must be reduced, since it means the furnace is not capable of heating sufficiently the volume of air being drawn through the stove. Once an inlet temperature has been decided on, it should not be changed. The best place to measure the inlet temperature is immediately below the bottom tray.

3. Adjust the inlet or fan valve to suit requirements; this will affect the inlet temperature, since it controls the amount of air

passing through the machine, and consequently the amount of air the stove has to heat. It should be as wide open as possible, since, as it controls the flow of hot air, it at the same time controls the amount of evaporation the machine can do. Any alteration of this type will probably necessitate further chimney damper adjustment in order to maintain steady inlet temperatures.

If the machine is not working up to stated capacity when this valve is full open and the furnace is in order, then it means there is not enough air to do the required work, and the fan speed must be increased.

In many cases, however, the fan or inlet valve has to be closed down a little to avoid excessive blow out of leaf from the dryer.

4. We have now set the capacity of the machine for evaporating a definite amount of moisture — by delivering a constant volume of hot air at a constant temperature. Accordingly we must feed that amount of dhool which contains neither more nor less than this amount of moisture. Since different dhools have different moisture contents, we must vary the load according to the dhool.

How are we to know when we are exceeding the amount of moisture we have decided to feed to the machine, and for the evaporation of which the machine is adjusted ?

We do not have to think very hard to find the answer, for we know that the temperature of the exhausted air depends on the amount of work it has been called upon to perform. The procedure is, therefore, to feed the machine in such amounts as will maintain a steady exhaust temperature. A thermometer which the feeding cooly can easily see, is one of the essentials of a tea drying machine. Care should be taken to see that it records accurately. It is sometimes difficult to find a suitable place for an exhaust thermometer, but it is worth the trouble to devise a means of ensuring that the temperature above the top tray does not fall below 120°F. as the very lowest limit, and of ensuring that the cooly feeding the machine understands that he is not to overload the machine so as to cause a low exhaust temperature.

In suction machines, leakages of cold air inwards through the feeder may cause the exhaust thermometer to give low readings, and consequently false information. On the other hand, in any machine, leakages of hot air up the sides of the trays may give high readings, which do not represent the true state of affairs. Such defects should be looked for and receive attention.

The moisture content of the discharged tea should also be measured. If it is constantly too high or too low, the time of passage through the dryer should be adjusted.

To summarise our views, we find that our object is to convert the fermented leaf to a stable product.

To do this we have dried it down to a low moisture content and have endeavoured to accomplish this as efficiently as possible, allowing the leaf temperature to be raised as much as is compatible with rapid evaporation.

The *particular* aspect I wish to stress is the importance of adequate destruction of ferments or, as the biochemist calls them, enzymes, when their useful work is finshed, so as to prevent deterioration after firing.

In order to accomplish this, the leaf temperature must be raised high enough to bring about this destruction of ferments in a comparatively short space of time. Several experiments on drying down tea without the use of heat have all produced teas which deteriorate rapidly. This is no doubt due to the fact that ferments were not destroyed.

At the present moment there is not any exact information upon the temperature and time required, but 160°F. for 15 minutes is suggested as being sufficient for the purpose. Since this question appears to be one of fundamental importance, we hope to get more data on the limits of required conditions.

Unfortunately, ferments in tea leaf are difficult substances to measure quantitatively, and a large amount of purely biochemical work is required to clear the ground for factory application. A certain amount of work has been done and there is hope of future progress.

The alternative is to carry out very accurately controlled firing tests, which we hope to be able to do with an experimental dryer now being designed. The teas from such tests will ultimately have to stand the test of the journey to England. The activity of ferments is dependent on the presence of a certain amount of moisture. Thus, a tea which is fired to a low moisture content, and kept in this condition is not very liable to deteriorate even if some ferment remains. On the other hand, if in addition, the ferments have been destroyed to a large extent by firing, the tea is not so liable to deteriorate if it does absorb a certain amount of moisture. If too much moisture is absorbed, however, after the tea has been fired, it is liable to be subject to mould or bacterial growth, and so I wish to stress the great necessity for checking the moisture content of made tea in every case.

Even the most experienced man cannot judge the moisture content of made tea by handling alone, and since the apparatus for carrying out these tests is so easily available, and so easy to work, its absence from a factory is to be deplored.

My experience has been that those factories which have referred the question of deterioration of tea to the Institute are those without apparatus for determining moisture content. There has not been a single exception to this within my experience.

We have been in the habit of advising 4% moisture content as a figure to aim at for tea despatched from the factory. On following up the moisture contents of teas between an estate and the London auction we have found 3% rise in moisture content to be of common occurrence.

The present methods of packing teas leaves considerable room for improvement so far as air-tightness is concerned. Foil which is merely folded cannot of course be claimed to give any protection against rise in moisture content.

This state of affairs often makes teas containing residual ferments liable to deterioration, and, in these days of competition to sell rather than to buy tea, lack of keeping quality is a much more serious matter than it used to be and thereby gains more notice.

V.

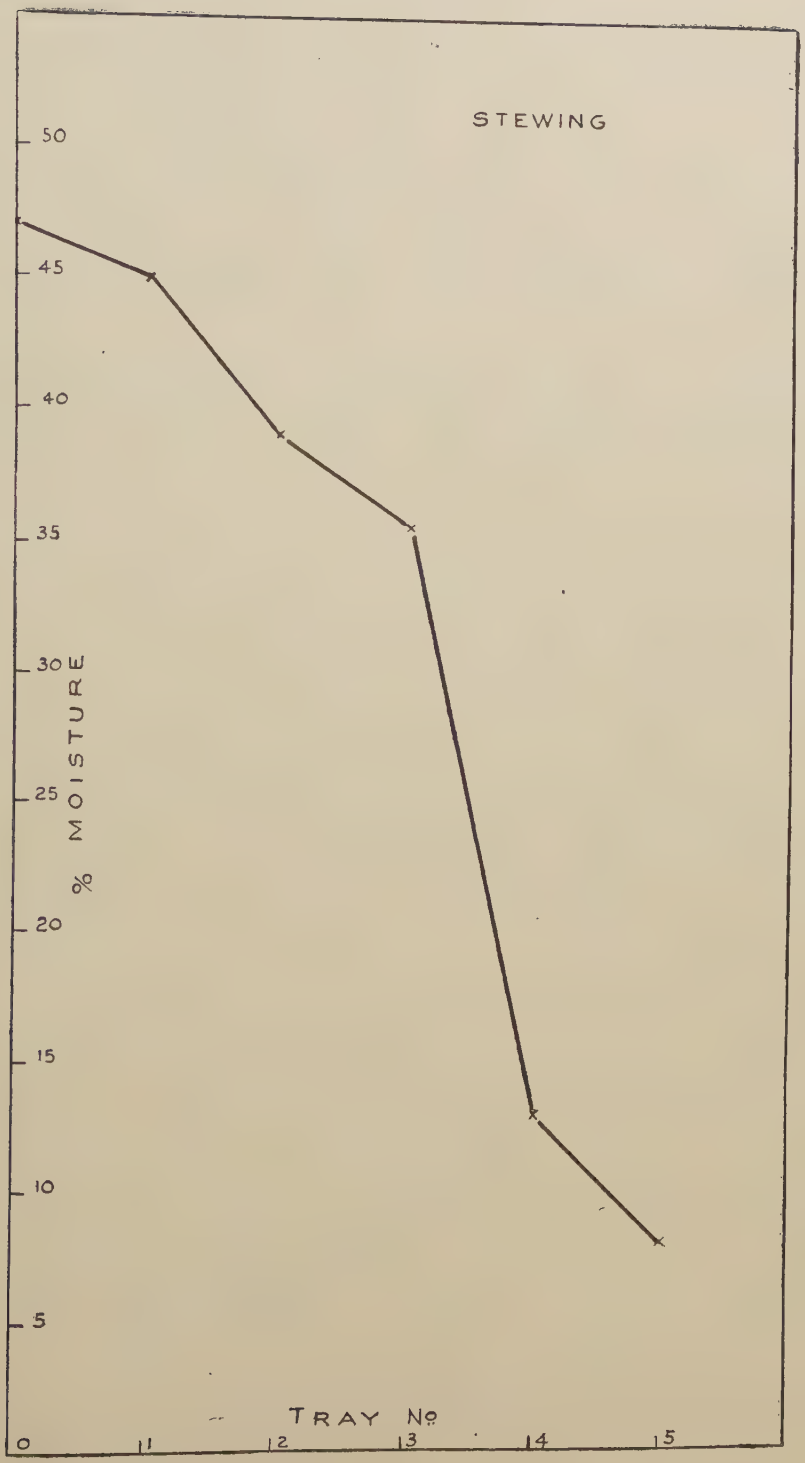
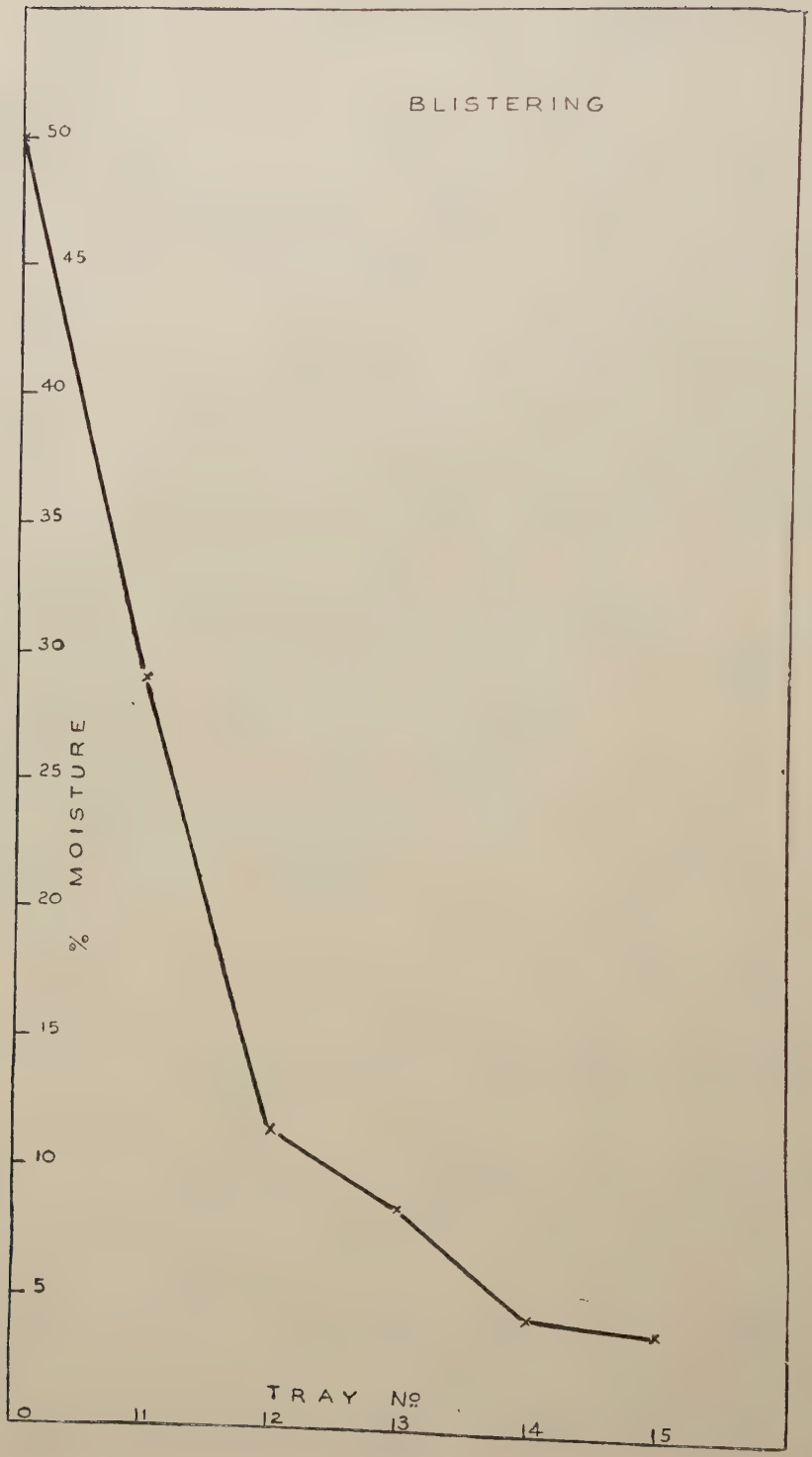


PLATE VI.


BLISTERING
50
45
40
35
30
25
20
15
10
5
% MOISTURE
0
11
12
13
14
15
TRAY No.

On these premises alone I therefore submit that exhaust temperature and moisture contents warrant the most careful attention.

I should regard 120°F. as the very lowest temperature which exhaust air should be reduced to, and should feel much happier about 130-135°F. For moisture content, 4% appears to be a safe figure at which to despatch teas. This will probably mean firing to about 3%.

The question of final firing fits in at this point, and here again I would stress the importance of checking moisture content by actual measurement. We still receive a large number of final fired samples in which the moisture content has not been reduced, and in some cases it is even higher than it was initially.

Final firing may play an important part in carrying out further destruction of ferments and from this point of view a temperature of 160° fits in with the figure already cited in this connection.

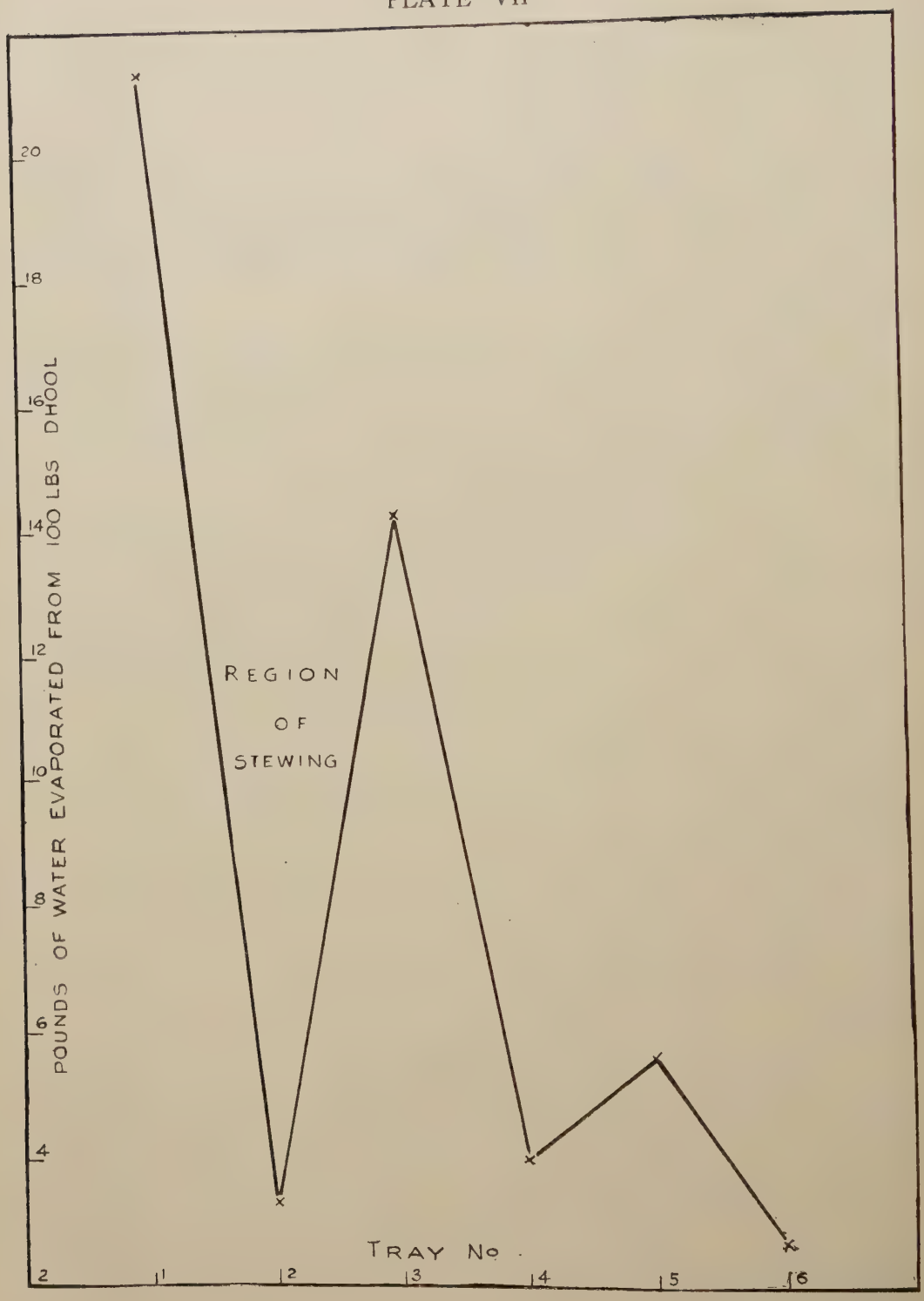
We have preliminary experimental results in hand which suggest that final firing may improve keeping quality through factors other than moisture content alone. Further experiments must be made before these results can be established.

The recommendations I have made, fit in with other aspects of the firing process. For instance, high exhaust temperatures are not often compatible with "Stewing", which is the acknowledged enemy of quality and flavour. Furthermore, the aromatic constituents of tea are only volatile in water vapour and can only be driven off to any serious extent under stewing conditions.

Before concluding this paper I should like to indicate very briefly some of the ways in which we can co-operate with the planter and the engineer in studying firing difficulties.

Firstly, we are willing to determine a limited number of moisture contents where the apparatus is not available, and for this purpose it is essential that samples shall be packed in tins such as those on view. As you will see, the tins are ordinary cigarette tins sealed by forcing the lid on over Dunlop $\frac{5}{8}$ in. insulating tape folded over the rim of the tin. The patent cutter is also sealed off with a separate piece of tape.

PLATE VII


POUNDS OF WATER EVAPORATED FROM 100 LBS DHOOL
20
18
16
14
12
10
8
6
4
REGION
OF
STEWING
TRAY No.
2
1
2
3
4
5
6

Unless packed in this way samples may gain or lose moisture in the post. Lead packets usually arrive in a hopeless condition.

In examining dryer efficiency it is sometimes necessary to study evaporation as the tea moves through the machine. Plate IV, indicates how this rate of drying may be determined. The machine is stopped and samples taken from the left and right hand side of each tray, from such a position or at such a time that passage to the next tray is about to occur.

The moisture contents of these samples are then determined and curves plotted. Indications may thus be given of uneven drying on the two sides, stewing, or blistering conditions. The two latter conditions are illustrated by Plates V and VI.

The graph in Plate VII is plotted for the amount of evaporation from 100 pounds dhool on each tray, which figures may be calculated from the moisture contents. This curve shows up stewing conditions which are not obvious on the simple moisture curve as illustrated in Plate IV.

II.—DISCUSSION.

Mr. E. E. Megget, referring to the question of lead foil and the possibility of damage during transit, asked Mr. Lamb what increase of moisture took place before the teas reached London.

Mr. Lamb stated that he had no comparative figures for different kinds of packing materials, but increases of three per cent. in moisture had been observed between despatch of teas from Ceylon estates and arrival in the London auction.

Mr. Morford asked what happened to the tea after it left the drier, did it pick up a great deal of moisture while cooling off or was it fairly safe for a few hours until put into the bins?

Mr. Lamb in reply stated that the tea should not be exposed to currents of damp air. If damp air came into contact with freshly fired tea, the latter absorbed moisture rapidly.

Mr. Murdoch asked if Mr. Lamb could suggest any special rate at which final firing should be carried out.

Mr. Lamb said he was afraid it was impossible to give definite figures as these would depend on the condition of the tea and the amount of moisture which had to be removed. He would, however, suggest a temperature of 160° for a period of 10-15 minutes.

Mr. Blackmore asked if the teas should be allowed to cool off before being put into the bins.

Mr. Lamb said that this should be done and, in reply to a further question from Mr. Blackmore in regard to the occurrence of case-hardening, he suggested that where firing trouble was suspected, samples from the two sides of each tray should be taken and sent in for examination. It would then be possible to say whether the conditions were such as to lead to case-hardening or blistering.

Mr. R. C. Coombe, referring to complaints regarding deterioration of Ceylon teas, asked Mr. Lamb whether he considered one of the contributory causes leading to inferior keeping qualities was the use of thin foil instead of the thicker foil used in days gone by with Momi chests. He said many persons were using this thin foil on instructions, and he would be glad to know if its use contributed to a possible loss of keeping quality.

Mr. Lamb replied that he would definitely say that such thin foil was often one of the contributory causes in cases where deterioration occurred.

Mr. John Horsfall said that very thin foil was definitely difficult to solder down and hence it was not easy to make an air-tight container with it.

Mr. Coombe expressed the hope that the Institute would give prominence to this point and say that they considered the use of very thin foil was detrimental to the good name of Ceylon tea.

Mr. Durbin said he understood Mr. Lamb to recommend a moisture content after final firing of about 4%. On the Baird & Tatlock's moisture determination machines the optimum was shown between 5 and 6 and he thought that figure was more usually adopted when sending teas home.

Mr. Lamb replied that his point was not that teas would not keep with a moisture content of 6% but that such a figure did not give a sufficient safeguard if further moisture absorption took place. Teas not infrequently absorbed 3% moisture in transit and a final moisture content of 9% would certainly be too high.

Dr. Norris in reply to **Mr. Scott,** who suggested that 4% was a very low figure, said that further experience had shown that the moisture taken up during transport to London was often rather higher than had been previously envisaged. He quite agreed no one wished to come down to a lower moisture content figure than was really necessary as they would then be doing unnecessary work and the tea would be losing unnecessary weight. But if the tea was liable to pick up 3% moisture he thought they should work to a lower figure than 6% to be on the safe side.

Dr. Norris went on to say that the question of deterioration could be solved more easily if proper records were maintained by estates. The Institute had

always been pressing for that to be done. They could have gone very much further into cases of deterioration if more data had been available, but in many such cases they had not been able to obtain details of the conditions under which deterioration had occurred. Pending further information he thought they were bound to take a conservative view in regard to permissible moisture content.

Mr. B. E. C. Oliveira asked if it would be possible for the Tea Research Institute to investigate some other sort of wrapping for tea chests, such as Celophane for example. The latter was easily obtained and it would be interesting to see how tea kept when so packed.

Mr. Lamb said the question of such packing material was rather a specialised trade, and he thought this was more a matter for commercial firms to take up. It would be difficult to go into such a question until they could obtain very definite figures of cost. He could, however, test out materials that might be suggested.

Mr. Oliveira pointed out that Celophane was already used as a packing material for many articles, *e.g.*, chocolate; it was cheap and could be satisfactorily sealed, and he thought it would be worth while going into the matter further.

Mr. Eden considered that Celophane was quite unsuitable as it was not impervious to water vapour. This could be demonstrated in his laboratory.

Mr. Ridler said there were one or two questions he would like to ask in regard to the keeping qualities of tea. Mr. Lamb had said in his paper that the enzymes would be destroyed by a temperature of 160° for 15 minutes. By that he assumed Mr. Lamb meant leaf temperature. If so, he would like to know at what stage the leaf reached that temperature; on what tray of the drier could one expect to obtain it. In experiments carried out by him he had found the leaf temperature to be less than 90-95°.

Another point was the final moisture content of 4% recommended by Mr. Lamb. He thought that was perhaps, going a little too far. It had been suggested to him that if tea were dried down too far, say to 2%, something was taken out of the tea which could not be restored. He thought that in the desire to get down to 4% there might be a risk of going too far in the other extreme.

Mr. Lamb said he agreed with Mr. Ridler that there was a danger in going too far and that drying could be carried to extremes. He did not think, however, there was any practical difficulty in the figure he had suggested.

With regard to leaf temperatures, the point he had made was that a temperature of 160° for 15 minutes was sufficient for complete inactivation of the leaf enzymes. He could not, however, say if such temperatures were attained,

and a lower temperature might prove to be effective. It was a point which would be investigated when the new experimental dryer referred to in his paper was available.

Mr. Baillie-Hamilton asked whether the temperature attained in sun drying was sufficient to destroy the ferments.

Dr. Norris said he was glad the question of sun drying had been raised as he was anxious to obtain information in regard to the keeping qualities of tea dried in this way.

Mr. Patterson stated that he had had some experience of sun drying. In his opinion the important point was not so much the sun temperature as the hygrometric difference of the air. His sun dried teas had been final fired.

Mr. Lamb pointed out that enzymes were rapidly destroyed by ultra violet light and this would no doubt play a part in sun drying.

The Chairman said he would like to thank Mr. Lamb for his very interesting paper and also all those present for attending the conference and taking part in the discussion. He thought the attendance this year was a record though Mr. Coombe claimed last year was better. He hoped as many visitors as possible would visit the laboratories the next day and have a pleasant and instructive time.

In conclusion, he wished once more to stress the importance of personal contact with the Institute staff and asked those present to cultivate this to the best of their ability.

The Conference was then closed.

TEST OF A MARSHALL'S NEW "EMPIRE" TEA DRYER.

J. LAMB.

The cost of firing is by no means an insignificant item in the total cost of manufacture, and in the course of a year the sum lost through the use of an inefficient firing machine may amount to an appreciable sum.

Data of the performance of different types of dryers under specified conditions will, therefore, be of interest, and details of a test carried out on a Marshall's New "Empire" Dryer are given below.

In this test the machine was worked continuously over a period of time sufficient to give the characteristic of the dryer. The characteristic is expressed in terms of British Thermal Units required to evaporate a pound of water from the leaf at specified inlet and exhaust temperatures, the latter being maintained at a steady figure throughout the test.

It is realised that it is sometimes difficult to keep a firing machine full during the whole period of ordinary routine firing. Failure to do so will of course add to the cost of firing, but the cost still depends mainly on the efficiency of the machine in use. The same applies when the machine is used to generate hot air for withering. The purpose of the test was to find the efficiency of the machine as a water evaporator under specified conditions, which efficiency can be compared with that of other machines under similar conditions.

Date of test—11th July, 1934.
Size of machine—6 feet.
Fuel used—Firewood.
Time of lighting up—9-30 a.m.
Time when first leaf was fed into machine—11 a.m.
Weight of firewood used in heating up—200 lbs.

The calorific value of the firewood used was 6,602 British Thermal Units per pound, so that the heat required to warm up the dryer was 1,320,400 British Thermal Units.

The weight of dhools fed, together with their moisture contents, before and after firing, are given in the following table. The calculated weight of made tea serves as a check of the accuracy of the moisture assay. There is very close agreement, viz. 1,230 pounds against 1,206 pounds actually weighed.

TABLE I.

Bulk	Weight	% Moisture	Weight of water	Calculated weight of made tea
	lb.		lb.	lb.
Special dhool	86·5	51·3 (Initial) 2·7 (Final)	43·2	43·3
Dhool 1	69·5	57·1 3·3	38·7	30·8
Dhool 2	109·5	54·3 2·5	58·2	51·3
Dhool 3	131·0	53·5 2·7	68·4	62·6
Dhool 4	128·5	53·8 2·8	67·4	61·1
Dhool 5	230·5	64·0 2·3	122·0	108·5
Dhool 6	714·5	54·3 2·3	380·3	334·2
Big Bulk	1,180·5	55·9 3·3	642·1	538·4
Total	2,650·5		1,420·3	1,230·2

The curves in Figure I are plotted to show the rates of feeding of dhool and firewood together with the rate of out-turn of made tea. The relationship between the three quantities of material may then be obtained by interpolation between two vertical lines from the time axis.

The "straight line" nature of these graphs indicates regular performance.

PLATE VIII.

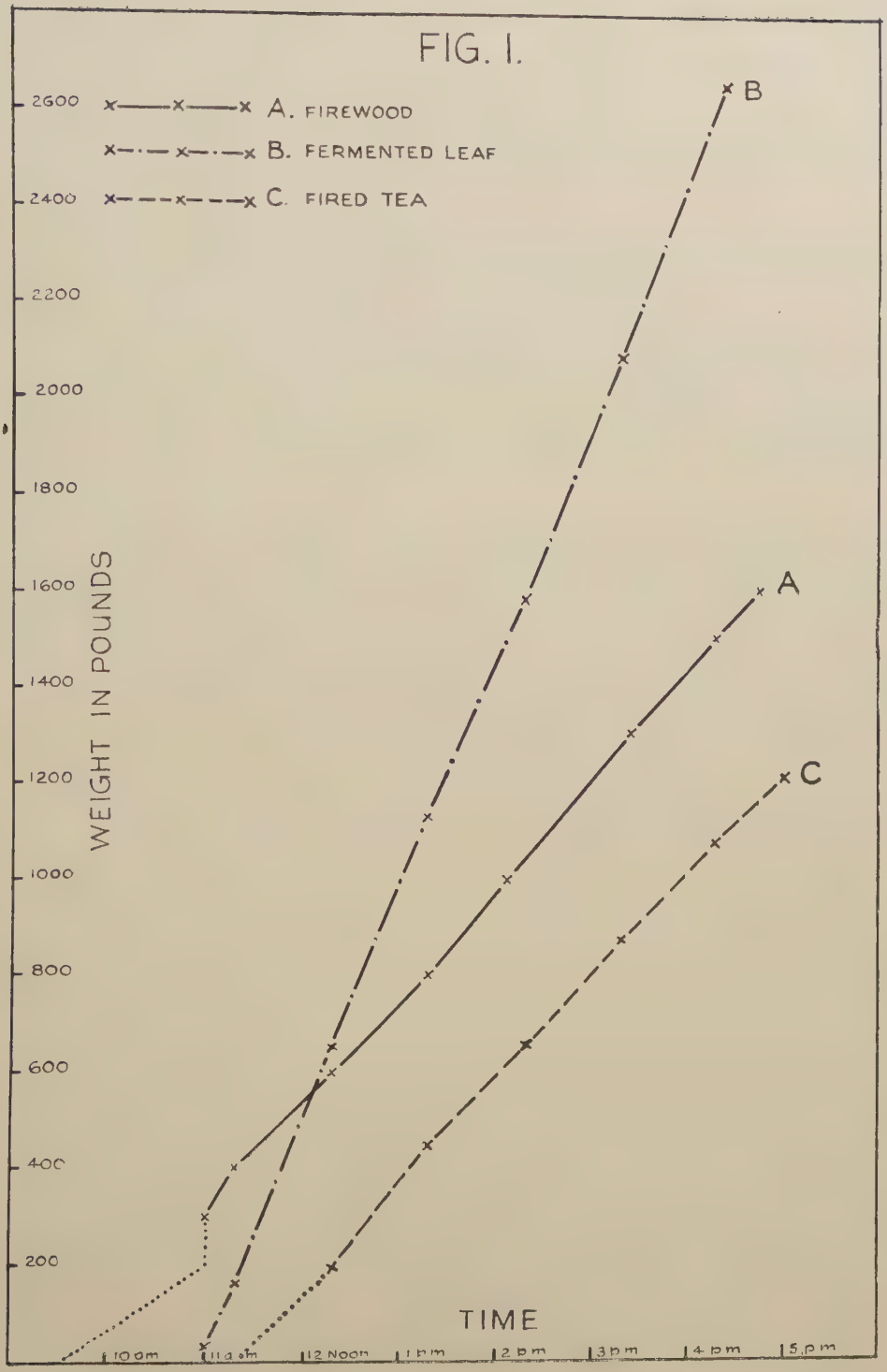
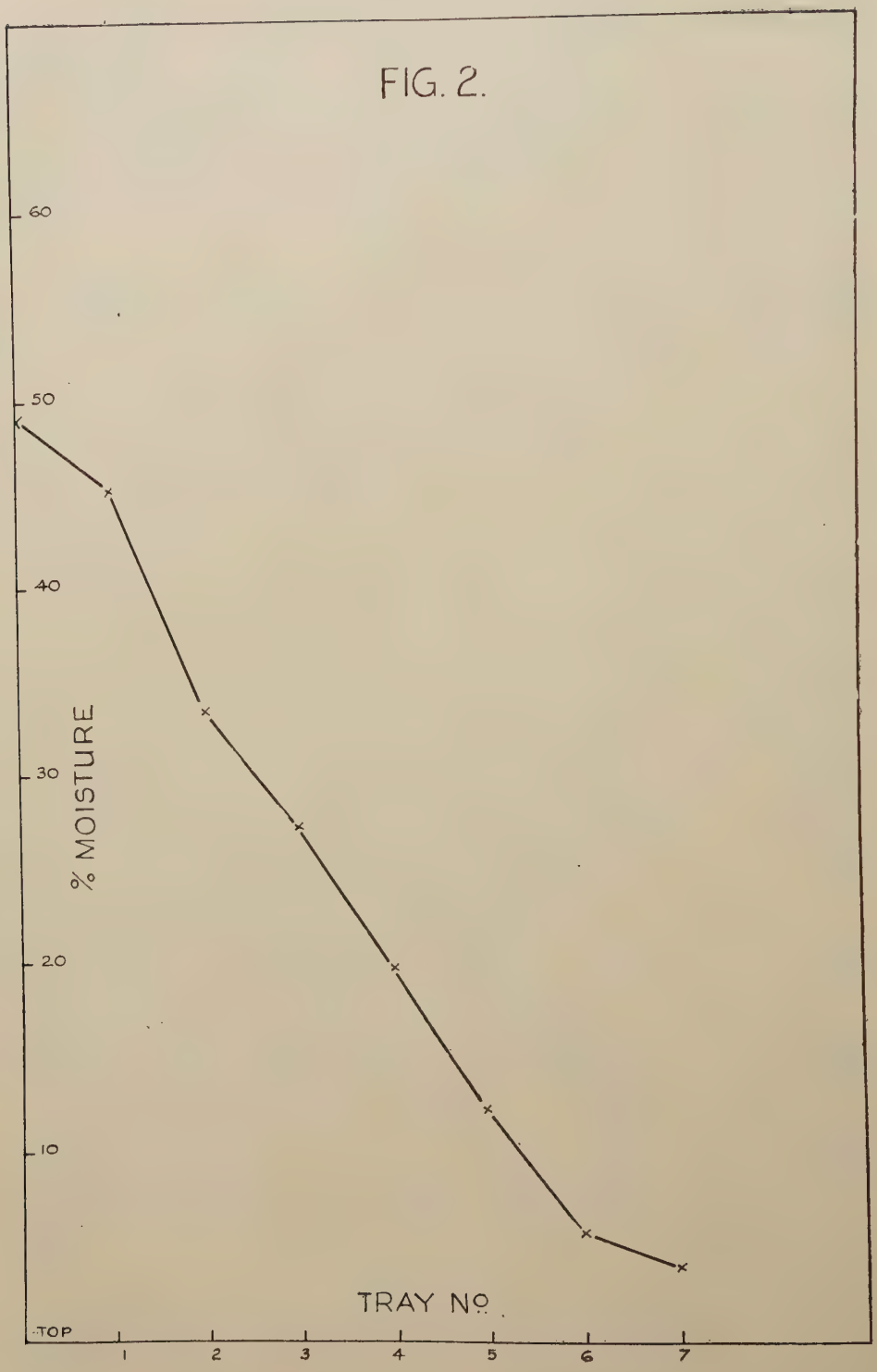


FIG. I.
A. FIREWOOD
B. FERMENTED LEAF
C. FIRED TEA
WEIGHT IN POUNDS
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
A
B
C
TIME
10 am
11 am
12 Noon
1 pm
2 pm
3 pm
4 pm
5 pm

PLATE IX.

FIG. 2.



The amount of water evaporated from the leaf was 1,420·3 pounds, and this required the use of 1,300 lbs. of firewood. The calorific value of this firewood was again 6,602 British Thermal Units per pound. 1,420·3 pounds of water were, therefore, evaporated with $1{,}300 \times 6{,}602$ British Thermal Units. The time taken was 325 minutes. Hence:—

One pound of water was evaporated with 6,040 British Thermal Units, and 262 pounds of water were evaporated per hour.

In cruder practical units 1,206 pounds of tea were dried with 1,300 pounds of firewood, excluding wood used in heating up. The out-turn of made tea on fermented leaf was 45·5%, the moisture content of the latter being 55·6%. 223 pounds of made tea were turned out per hour.

The time taken to pass through the dryer averaged 20 minutes with an inlet temperature varying between 200 and 210°F. and an exhaust averaging 129° over the top tray. The fan revolution varied between 450 and 470.

It is possible that more efficient working would have resulted from a slightly larger load but this would have meant a lower exhaust temperature.

The flow of air is unfortunately very difficult to determine accurately but can be approximately calculated from the hygrometric readings taken:—

Average Temperatures	Exhaust, 129° Dry. 95° Wet.	equivalent to 1·710 lb. water per 1,000 cu. ft.
	Outside, 80° Dry. 70° Wet.	equivalent to 0·938 lb. water per 1,000 cu. ft.

Now at 129°F., 1,000 cubic feet of outside air will contain 0·925 pounds of water. Therefore, water carried off by 1,000 cubic feet = $1{,}710 - 0{\cdot}925 = 0{\cdot}785$ pounds. Since 1,420·3 pounds of water were evaporated, air flow $= \frac{1{,}420{\cdot}3}{0{\cdot}785} = 1{,}810{,}000$ cubic feet, and as the test ran for approximately 325 minutes the air flow per minute = 5,500 cubic feet. Anemometer readings indicated a higher rate of flow of air but varied unduly according to the method they were taken by.

Moisture determinations done on tray samples taken at the end of each tray, just before the tea was due to fall on to the next tray revealed an even rate of drying. (Table II).

TABLE II.

	Mean	Right	Left
Top	49·1	49·3	48·9
Tray No. 1	45·3	45·6	44·9
,, 2	33·6	36·7	30·5
,, 3	27·2	28·5	25·9
,, 4	19·7	22·6	16·8
,, 5	12·3	15·8	8·7
,, 6	5·8	6·6	5·0
,, 7	4·0	4·7	3·3
Bottom	—	4·8	—

A tube connected to a sensitive manometer was inserted between the stove and the dryer. The doors of the insulating casing immediately in front of the tubes were then suddenly opened. No difference of pressure was revealed, showing that the insulation does not impede the intake of air.

SUMMARY.

Time taken to heat up	90 minutes.
Firewood used to heat up	200 pounds. =1,320,400 B.Th.U's
Heat taken to evaporate 1 lb. water ...	6,040 B.Th.U's. =0·9 pound wood.
Water evaporated per hour ...	262 pounds.
Made tea per hour	223 pounds.
Firewood used per pound made tea exclusive of fuel used in initial heating up	1·08 pounds.
Calorific value of firewood	6,602 B. Th. U's per pound.
Moisture content of fermented leaf ...	55·6% average.
Out-turn made tea on fermented leaf ...	45·5%.

Out-turn calculated from samples taken for moisture content ...	.. 45·4%.
Moisture content of made tea	... 3% average.
Time taken through dryer ...	... 20 minutes, average.
Inlet temperature ...	... 200-210°F.
Exhaust temperature ...	... 129° average dry bulb. 95° wet.

The firewood used in this test was rather damp, containing 26·6% moisture. The weights of firewood used were, therefore, higher than one might have obtained with drier material.

NOTICES.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

Publications.—Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not to the Director's Office.*

ROLAND V. NORRIS,
Director.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 11-12-34.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held in the Ceylon Chamber of Commerce Rooms, Colombo, on Tuesday, the 11th December, 1934, at 10 a.m.

Present.—Mr. James Forbes (Jnr.) (Chairman), the Hon'ble the Financial Secretary, Col. T. G. Jayewardene, V.D., M.S.C., Messrs. I. L. Cameron, C. E. Hawes, J. C. Kelly, D. T. Richards, B. M. Selwyn, A. W. L. Turner (Secretary), S. C. Bisset (Accountant) and by invitation Dr. R. V. Norris (Director, Tea Research Institute of Ceylon) and Mr. J. W. Ferguson (Visiting Agent of St. Coombs).

Absent.—The Director of Agriculture, Messrs. R. G. Coombe, M.S.C , D. H. Kotalawala, M.S.C., and J. D. Hoare.

1. Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 14th September, 1934, were confirmed.

3. MEMBERS OF THE BOARD OF THE T.R.I.

The Chairman welcomed Mr. I. L. Cameron on his return from leave and thanked Mr. R. A. Sharrocks for having acted as a Member of the Board during Mr. Cameron's absence.

As that was the last meeting Mr. Kelly would attend, he thanked him for the great assistance he had rendered throughout his term of office and especially in connection with the new form of Balance Sheet, which the Hon'ble the Financial Secretary had suggested should be adopted.

The Chairman announced that the following Members would automatically retire from the Board on the 31st December, 1934, in terms of Sections 5 (1) (b) of Ordinance No. 12 of 1925:—Mr. R. G. Coombe, M.S.C., representing the Planters' Association of Ceylon, Major J. W. Oldfield, C.M.G., O.B.E., M.C., representing the Ceylon Estates Proprietary Association and Mr. D. H. Kotalawala, M.S.C., representing the Small-holders. The Ceylon Estates Proprietary Association had nominated Major Oldfield for a further period of three years and the Planters' Association of Ceylon would nominate a Representative in January next.

4. FINANCE.

(a) *Statement of Accounts as at 31st October, 1934.*—This was adopted without comment.

(b) *Estimates for 1935.*—The Chairman explained that both the Research and the Estate Estimates had been very carefully examined by the Finance Sub-Committee who had made sundry small alterations, and the Estimates before the Board that day were those recommended by the Finance Sub-Committee for approval.

After discussion, Mr. Hawes seconded by Mr. Selwyn proposed that the Estate and Research Estimates for 1935 be adopted.

This was agreed to.

(c) *Auditors.*—Messrs. Ford, Rhodes, Thornton & Co. were re-appointed Auditors for 1935.

5. SENIOR SCIENTIFIC STAFF, T.R.I.

(a) *Dr. R. V. Norris (Director).*—Announced that this officer returned from special leave and resumed his duties as from the 8th October, 1934.

(b) *Dr. C. H. Gadd (Mycologist).*—Announced that this officer returned from leave and resumed his duties as from the 22nd October, 1934.

(c) *Mr. F. R. Tubbs (Plant Physiologist).*—Announced that this officer proceeded on furlough on the 31st October, 1934 and is due to return to duty on the 6th August, 1935.

6. ADDITIONAL SMALL-HOLDINGS OFFICER,

The Director said that an additional Small-holdings Officer had been provided for in the Estimates. He suggested that Baddegama in Galle District would be a suitable station for this additional officer.

It was agreed that the Director should take the necessary steps to obtain an officer and that he should consult Mr. D. H. Kotalawala as to the District in which the officer should be stationed. The final appointment to be made by a Selection Committee.

7. EXPERIMENTAL SUB-COMMITTEE,

The Minutes of the Meeting of the Experimental Sub-Committee held on the 13th October, 1934, which had been sent to each Member of the Board on November 29th were passed without comment.

8. T.R.I, CONFERENCE, 1935.

It was agreed that this should last for $1\frac{1}{2}$ days, the first day being occupied with the Conference and the following morning with inspection of the Laboratories and Estate, and that the Conference should be held on March 1st and 2nd.

With a vote of thanks to the Ceylon Chamber of Commerce for the use of their Room and a vote of thanks to the Chair, the Meeting terminated.

A. W. L. TURNER,
Secretary.

EDITORIAL.

We are glad to be able to announce that Mr. Eden. the Institute's Agricultural Chemist, has been awarded the degree of Doctor of Science (D.Sc.) in the University of Manchester and Mr. Tubbs, the Institute's Plant Physiologist, the degree of Doctor of Philosophy (Ph.D.) in the University of London.

It is a matter for gratification that the work of these two officers, which has already received wide recognition for its practical utility, has now been accorded the cachet of academic approval.

"TAY."

Any discovery which may lead to a greater utilisation of tea must be of interst to producers and we reproduce therefore some of the remarks of the Chairman of the Indian Tea Cess Committee at the half-yearly meeting of the Committee. Mr. Milligan said:—

> "In America a really good tea-syrup has been invented as a result of 12 years of experiment. A teaspoonful of this syrup added to hot water makes a very good cup of tea. It also makes an excellent aerated drink, and a first class brew of iced tea. So convinced was I of the value of this discovery that I strongly recommended the American and Foreign Markets Sub-Committee in London to have a small plant erected in New York and give the syrup a thorough trial. I went into the question of securing to the Indian Tea Bureau full rights in this discovery and this, I believe, will have been accomplished by now. The vast potentialities of such an essence are too obvious to require elaboration. If the forthcoming experiment of putting it into consumption in America is successful, the popularising of this syrup would, by itself, justify the whole of the proposed campaign in the States. The stupendous consumption of Coca-kola is due to the "kick" which is imparted to the drink by the caffeine content — derived from India's exported tea-waste principally. Our new carbonated beverage, to which it has been proposed to assign the name of "TAY" will have an identical "kick" and a very much more refreshing and attractive flavour. I predict for it a great future not only in America but in India and the world generally."

DRYER TESTS.

We regret that in the report of the firing tests on a Marshall New Empire Dryer published in *The Tea Quarterly*, 1935, page 65, by a typographical error the size of the machine was given as six feet. Actually the machine in question was a "Small four feet". We understand that the normal out-turn of these dryers is as follows when firing in one operation and using leaf giving an out-turn of made tea to fermented leaf of forty per cent:—

3 feet machine	Out-turn	150/175	pounds	per	hour
Small 4 feet machine	,,	200/225	,,	,,	,,
Large 4 feet machine	,,	225/250	,,	,,	,,
5 feet machine	,,	275/300	,,	,,	,,
6 feet machine	,,	400/450	,,	,,	,,
7 feet machine	,,	400/550	,,	,,	,,

TOUR IN JAVA.

The Chairman and Director accompanied by Mr. P. H. Carpenter, the Chief Scientific Officer of the Tocklai Experimental Station, Assam, paid a visit to Java in April and a report covering this tour will shortly be issued.

Visits were paid to many estates, to the Thee Expert Bureau and the Thee Proefstation, while discussions were held with leading officials and business men.

The itinerary for the tour was kindly arranged by the Thee Expert Bureau, Batavia, and we should like to take this opportunity of thanking all those in Java who co-operated in making the visit such an interesting and instructive experience.

Mr. H. R. Cooper of the Tocklai Experimental Station will visit St. Coombs in July and Dr. Eden will spend a few weeks in the N. E. Indian tea districts in November.

BOOKS ON TEA.

A publication of wide interest to all those connected with tea either as producers or consumers is Mr. W. H. Ukers' book 'All

about Tea'* a companion, but on a considerably enlarged scale, to the same author's "All about Coffee". The present work, published in two volumes comprising 1,152 pages and approximately 600,000 words, is undoubtedly the most comprehensive book on tea which has been published and contains a mass of material collected over a long term of years from sources not readily available to the ordinary reader.

Volume I commences with an historical section from which we find that credible references to tea date back to so long ago as A.D. 350, while a handbook of tea was already in existence about A.D. 780. The use of tea through China and Japan, according to the author, was originally advocated by Buddhist priests as a means of combating intemperance. Whether western nations were in less need of such propaganda is to be doubted, but several hundreds of years passed before tea reached Europe where it was brought by the Dutch about 1610. A fascinating account follows of the development of the tea trade by the East India Company and the growth of the industry in India, Ceylon, the Netherlands East Indies and in more recent time in other countries.

The second section deals with the characteristics of the commercial teas of the world and gives a very full account of the methods of cultivation and manufacture followed in the various producing countries.

This is followed by a section on the scientific aspects of the industry which covers the botany, chemistry and pharmacology of tea, the latter two subjects being described by Mr. C. R. Harler, formerly of the Tocklai Experimental Station. The last chapter of this section contain a digest of opinions by medical and other authorities in regard to the "healthfulness" of tea and will provide material for counter-battery work against some of the wild statements that are made in regard to the alleged ill-effects of tea drinking.

The earlier chapters of Volume II deal with the marketing of tea and a very full history of the tea trade in various countries has been compiled. This is followed by a history of tea advertising

* *All About Tea* by W. H. Ukers, M.A. New York, 1935, The Tea and Coffee Trade Journal Company, Price $25.

and when one states that the advertising material dealt with extends from a "Memoir on Tea" published in A.D. 780 to the latest sayings of Mr. T. Pott, readers will obtain some idea of the immense amount of ground covered by this exhaustive work.

Volume II concludes with chapters on the social and artistic aspects of tea, and to housewives and probably to many others too this section will be one of the most interesting parts of the book.

Finally, there is a unique bibliography of tea containing full references to some 2,000 publications covering every branch of the subject. The book is excellently printed and profusely illustrated and a special measure of praise must be accorded to the quality of these illustrations.

Mr. Ukers is to be congratulated on the successful completion of this work which is likely to remain a standard book of reference in regard to tea. The book is intended to serve the general reader as well as those directly associated with tea and admirably fulfils this object.

ROLAND V. NORRIS.

COMPOST MANUFACTURE AND USE ON TEA ESTATES.*

T. EDEN, D. Sc.

During the last six months the subject of compost has occupied an important part of the time I have devoted to estate visits, correspondence and interviews. I cannot in one lecture deal in detail with all the points that have cropped up, but I propose to give a broad outline of the theoretical and practical problems that face anyone who embarks on this interesting adventure of compost manufacture. Some of the details will doutbless be filled in when discussion time comes

The best starting point for my present address will, I think, be a reminder of what I have previously said and written on the subject, and I will cover the ground as briefly as possible. In its original form, composting by the Indore process was a highly successful attempt to make use of *waste* vegetable matter, by fermenting crop residues with dung and urine in shallow pits. The result was a well-rotted homogeneous bulk manure. It was designed to meet the needs, and exploit the resources, of a system of annual crop husbandry which produces a very considerable quantity of crop residues from threshing, crushing or picking of crops such as grains, sugarcane and cotton. In their crude state many of these products were not suitable for direct applicaton to the land, but composting rendered them eminently so.

I pointed out in my previous lecture that such a profuse supply of easily collected material, not already used to conserve soil resources, was not generally available on Ceylon tea estates, and I predicted that in our case special material would have to be grown, or at least garnered in its place. With our somewhat difficult and primitive transport facilities, I foresaw an increase in cost of the finished

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* A lecture delivered before the Dickoya District Planters' Association on June 28, 1935.

material that would far outclass the low rates published from India. I quoted an estimate of Rs. 8·00 per ton, and suggested that experience would show ways of reducing that figure to a more manageable size. I still maintain that even under favourable circumstances, we cannot compete with the Indore figure of 50 cents per ton.

In Ceylon there are two classes of materials that may be made into compost:—

(1) Waste materials, *i.e.*, materials that would not normally find their way back to the land, such as weeds, factory sweepings, line refuse; and vegetation from outside sources, such as sunflower, manna-grass, and any kind of cut cheddy.

(2) Materials growing already on tea land, and already used in some form or other. These are mainly prunings and green manure loppings.

There is a very vital difference between these two kinds of material. The one is bringing in continually new nutrient material; the other is not.

Experience has shown that the majority of people making compost have been driven by force of circumstances in the shape of scarcity of *real waste material*, to use large proportions of prunings and green manures as the source of vegetable material. In this they have confirmed my prediction. At the same time they have completed the process at a much less cost. To what extent they have made a real saving, and not just a book-entry saving, we have now to enquire.

When I gave the figure of Rs. 8/- per ton, the assumption was that green manures in tea and prunings of tea would not be used for composting. If they are used, then obviously the process costs less because a vote already exists to cover the cost of lopping and pruning. But at the same time the compost is of less value because it is not supplying new humus and new nitrogen. On the financial side, it follows that we can afford to spend more per ton in producing compost from the waste materials class, than from the other class. To emphasise this important point thoroughly I will state it in

another way. If we find that compost is being made more cheaply from green manures and prunings, it does not inevitably follow that this method is more sound economically than that producing compost from waste materials only. You will see that the lie of the land has been radically altered, and I shall accordingly deal more specifically with what for brevity I will call green manure compost. By that I mean compost having a preponderance of green manure in its make-up.

We now have actual working costs over a period, for the daily manufacture of two tons. The proportion of green manures used is 60 per cent. and the cost works out at between two and three rupees per ton. This figure allows for some specially organised transport to supplement what can be arranged on journeys from the field by labourers returning to their quarters.

I am going to turn now to a more theoretical aspect of composting, but this seems a suitable place to draw your attention to the fact that, manufactured in the way described, compost application will have to be regarded as a substitute for green manuring rather than for artificial manuring. The balance between the two views will, of course, depend upon the proportions of outside materials used. I think it will be found that compost will be best applied shortly after pruning, but that at other periods in the pruning cycle, artificial manures will still have to be used

We have now to assess what possible benefits accrue from composting green manures instead of using them direct, since we are paying an appreciable sum of money for the transformation. Here we are on rather more controversial ground. It is held by some, including Howard himself, that direct green manuring confers no benefit to the associated crop, apart from the actual fact of growth of a leguminous species, and that the incorporation of loppings is harmful. I do not subscribe to this view in the case of tea, though I have been at pains from time to time to warn the community against the injudicious use of loppings in too late a stage of development. I do not think I am called upon to compare composting with bad

practice in green manuring. I will, however, go so far as to say that material not eminently suitable, on account of age, for direct application, will be rendered more suitable by composting. To that extent it is more foolproof. My main contention is that the benefits of composting are more demonstrable on annual crops than on perennial ones. I think it will be worth while to explain this in some detail.

Annual crops are sharply divided from perennials by requiring the constant production of a good seed bed, and by the very short period of their life during which they can usefully absorb nitrogen. For grain crops, a period of about two months only for optimum nutrient absorption has been observed. Now in the first place a seed bed tilth cannot be procured immediately after ploughing in green manure, but a good compost offers no difficulty. Then secondly, the successful use of green manures with annual crops depends on the products of decomposition being available at the critical time just mentioned. The ideal conjunction of conditions is seldom realized in practice. Either green manure is still unavailable when the main crop is planted, or the products of decomposition have been leached away. The former difficulty is likely to be caused by too little rain, and the latter by too much, through the impossibility of procuring a seed bed at just the right time.

Under these conditions, compost scores heavily because, if I may mix my metaphors, it first puts the green-stuff nutrients into cold storage for use at the appropriate time, and then, as the advertisements for patent cereal foods say, presents it in a 'predigested form'. But with a crop such as tea, capable of absorbing and using nitrogen throughout its life, except just at time of pruning, this particular advantage is at a discount, and superiority for compost cannot be claimed on these grounds.

In special cases some advantage remains with compost. There are still considerable areas of tea which for a number of reasons come into pruning in dry weather. As I explained at the Institute's Conference, the forking in of prunings then and there will only aggravate the drought conditions without conferring any nutritional benefit. A

mulch may be expected to help the preservation of moisture, but it is definitely a wasteful way of dealing with the nutritional side of pruning material. Under these circumstances compost can be made, for application at a more convenient season. The same sort of argument applies to those lopping operations in green manures which do not coincide with the cultivation programme. This material forms a suitable source of compost. For those who find that the climate is an enemy in the regulation of lopping and forking programmes, composting may be expected to ease the situation, since the lopping can be done when the shoots are neither too young nor too old.

I think I have dealt fairly with the green manure versus compost controversy, but when it comes to considering whether the estimated advantages are worth from Rs 15·00 to Rs. 30·00 per acre, neither I nor anyone else at present, can say. With costs of production cut to a low figure, I consider it is worthy of a trial and we intend to pursue the matter in formal experiments.

COMPOSITION OF INDORE COMPOST.

	Moisture Content	Nitrogen per cent. Dry Matter	Soluble Humus per cent. Dry Matter	Vegetable Material used
Ceylon	62	1·41	26·76	Green Manure 60 per cent.
	52	1·13	27·44	Green Manure 60 per cent.
	18	1·57	37·45	Weeds 70 per cent.
	50	0·73	20·62	
	34	0·89	18·47	Green Manure 65 per cent. Coarse Tea Leaf 31 per cent.
Indore	—	1·61	11·56	Cotton residues
	—	0·81	5·36	Mixed residues
	—	0·86	4·01	Weeds

Turning now to a new aspect of the subject, I can give you some information as to the manurial quality of Ceylon compost compared with the Indore product. It does vary considerably according to the individual manufacture and the material used; but on the whole because green manures are richer in nitrogen than annual crop residues, Ceylon compost should be richer than Indore.

This is borne out by our analyses, some of which are displayed in the table. There is a distinct difference in nitrogen and a greater proportion of what Howard calls 'soluble humus'. I have no information as to how Howard determined this. I have taken it to be easily oxidisable humus, and to some extent the term soluble humus is in my case a misnomer. At any rate the data show that a thoroughly useful product can be turned out.

In closing I merely want to underline certain points. The real value of compost is determined by the amount of new material not previously used, that contributes to its manufacture. This amounts to the transference of the fertility of hitherto unexploited land on to tea land.

The production costs when green manure is the chief source of supply must be watched, realising that the cost is additional to that of green manuring, but that the benefit is problematical except in special cases.

Finally, until more experience is forthcoming, composting should only replace green manuring and not the normal programme of artificial fertilisers.

TEA RESEARCH IN CEYLON *

F. R. TUBBS.

Before the Ceylon Association in London, Mr. F. R. Tubbs, M.Sc (Lond.), D.I.C., A.R.C.S., F.L.S., Plant Physiologist of the Tea Research Institute of Ceylon, on February 8 gave an address on the work of his department, in the Council Chamber of the Rubber Growers' Association, 19, Fenchurch Street, E.C. By invitation members of the Indian Tea Association (London) and the South Indian Association in London were present.

The President introduced Mr. Tubbs who spoke as follows:—

Mr. President and gentlemen, first I should like to thank your committee and yourselves for providing me with this opportunity of describing to you to-day some of my work and some of the data that have been accumulated in my department since I went out to Ceylon. You are interested in the success of your estates there; our job is to work upon the application of science and improved methods to those estates. Therefore, you are naturally interested in the results achieved and suggestions which we can make for the better carrying on of those estates. Your superintendents in Ceylon have the opportunity, of which advantage is very fully taken, of attending periodical lectures, but you do not have the same opportunities of hearing of our researches. Mr. Baynham has told me that there will be a short time available for questions after I have finished, and I hope you will take full advantage of it and ask me any questions you like I cannot guarantee to be able to answer them, but I will do my best.

The department of Plant Physiology, of which I am in charge, is the junior department of the Institute, but it has succeeded in getting a certain amount of information of some importance on certain phases of the work which has been going on, although in others five years naturally are far too short a period in which to get conclusive results.

* Report of a lecture given before the Ceylon Association in London on February 8, 1935.

Before discussing pruning problems, which were handed to me as my major line of investigation when I joined the Institute, I will first run briefly over certain other lines of work.

THE SELECTION OF TEA.

First is the selection of tea, which, as you know, is a very important thing. In practically every other crop in the world very far-reaching financial and economic results have followed upon the application of selection to the crop, but in tea we are up against very great difficulties. The tea seed bearer takes so long to fruit that to run over a series of generations would take far more than my lifetime. That is one of our major difficulties.

A second and even more fundamental difficulty is this: that so far there is no known method of estimating the quality of the tea likely to be derived from the produce of a single plant, because you cannot get that produce in sufficient quantities. It is obviously no use just propagating thousands of bushes on the off-chance of one of them being good. You have to go through and select your bush beforehand, and until chemical investigations have progressed considerably further there is little hope of selection making active progress: but when that does occur we shall need the vegetative propagation of tea. If we find a bush capable of giving a much better product we shall want to propagate that bush. For that reason the propagation of tea by vegetative means has been examined at the Institute as a side line, because there are other and more pressing problems to be tackled; we have just succeeded in getting our plant house built, and when I get back I hope to get on further with this work.

We have already made progress. For instance, I have worked out certain means of vegetative propagation which will enable me to start testing as to whether it is worth while cultivating for caffeine content or for tannin content. Vegetative propagation I have already shown to result in a considerable reduction in the variability of young plants I took seed derived from seed bearers of a very high standard and propagated some of the seedlings vegetatively, and vegetative

propagation did result in the production of more uniform plants. Uniformity is of prime importance, and there is no doubt that vegetative propagation will be valuable in this connection. For that reason we are carrying on work upon it.

GROWTH OF YOUNG TEA.

Another line of work, over and above the work on pruning, is those factors which affect the growth of young tea. Investigations have been carried on into the effect of the size of the seed. It was found that large tea seed definitely gave better plants, and more rapidly growing plants, than small seed, but that in a practical sample very little variation was to be found due to seed size, this being due to the fact that when the seed is collected all the smaller seed is re-removed. But this work does definitely point the moral that it pays to get good-sized seed, and, if necessary, to pay a little extra for it.

Shelling the seed, removing the hard outer shell, was also found to increase the growth of seedlings. It is too difficult a process for the coolie, however. That is one difficulty we are up against the whole time. We can advocate methods, but unless the coolie is capable of applying them it is little use for us to advocate them. That, of course, restricts considerably the lines on which we are able to work. However, it does appear that cracking the seed would be an advantageous process when setting down nurseries, leading to more rapid and more even germination.

Experiments have also been carried out in the treatment of two-year-old stumps. Five methods of planting were tested, and the results have been reported in *The Tea Quarterly*.

An interesting point which has emerged from the experiments is that the presence of lateral roots on the stumps had no effect upon either the establishment or the subsequent growth of the plants. Stumping them instead of leaving them standing up as they were in the nursery does reduce growth immediately, but it is possible that it is made up for later.

One conclusion was drawn from that work, and that was that in planting in old tea it was advisable to plant stumps which had not been cut back to six inches, or four inches, or even three inches, but

just to remove the leaves, the lateral roots, and all the green stems, and leave a woody stump, possibly some 3 ft. long, standing up. They establish quite well —as well as ordinary stumps — but they produce new shoots near the top of the stem. The result is that the coolie does not knock them about when plucking, and they are more able to compete with the surrounding big bushes. This is one of the planters' difficulties — the establishment of supplies in old tea. It is a very difficult thing, and a costly one. The process I have mentioned appears to be an advantageous method of tackling the problem, and has already been adopted on a large number of estates in Ceylon, and by the time I get back I shall be able to see whether practical experience has backed up the result of my experiment, as I certainly expect it to do.

Then there is the question of the pruning of young tea. An experiment is now in progress of which there are not yet sufficient results to talk about. Four methods of pruning young tea which are advocated by prominent planters are being compared.

Another line of investigation I took up was carried on in co-operation with the entomologist. He had been told that nettle grub, the largest thorn in the side of some estates in Ceylon, was reducing wood growth. In the field it is impossible to tell. You wander round estates, and it is stated that one man's wood has improved, while another man's wood has gone back, but it is practically impossible to make certain by visual inspection. I tackled the question on a measurement basis. Stripping the bush of its leaves reduces the crop, and the wood growth is reduced considerably.

Here, again, matters of practical policy arise. If a bush has been very badly attacked by insect pests, such as tortrix or nettle grub — especially the latter, which removes all the leaves, old and young, from the bush, other such pests which damage leaves being mosquito blight and Circosporella — it should be rested, levelled off, and then brought into plucking again, but where you are going to prune to try to eliminate the pest, that pruning should be done before new growth starts again. It is not worth while letting the nettle grub go on for

possibly a month before you prune. If you are going to prune to eliminate nettle grub, do it as soon as the attack warrants it. Otherwise you are not going to get such good growth after pruning.

Another point which came up was the effect of the time of year at which pruning is carried out, upon the severity of tortrix attack. To measure the severity of attack is extremely difficult. You cannot very well measure how much leaf it has eaten, or how the grubs increase in size, or anything like that. What we go on is the number of egg masses collected. It was found that in Dimbula pruning at the end of April, at the end of the tortrix season, very considerably reduced the tortrix attack on those plants in the subsequent tortrix season, but only for that one season. The time of pruning, therefore, does influence that attack of tortrix, but only for the one subsequent season. Thereafter things become uniform again.

An interesting point is that, when people say that tortrix has disappeared, it has not done so, normally speaking; it is still there. To investigate that question I had collections made on my pruning plots right through one South-West Monsoon — one of the worst we had had for some time—and egg masses, grubs, and an occasional moth were found throughout the period. They were not found, of course, in large quantities, but they were the basis for the subsequent attack when weather conditions became more favourable. It really looks as though it were these that we ought to attack — not to concentrate only upon collecting tremendous numbers of egg masses after an attack has begun, but also to deal with those early egg masses just before the tortrix season begins. It seems as if routine collection over the fields just before the tortrix season might be the most effective preventive.

Another thing which cropped up was the relative inefficiency of the tortrix collection, even on the scale on which I did it, which is more than most estates could afford. I was collecting over nine-day intervals, and if they were being collected really efficiently the attack should have been wiped out, save for reinfection from outside, but it went on through the whole season. The method of collection of the egg masses does not seem to be as efficient as it should be.

RESTRICTED CROP.

Another line of investigation, which came up in connection with restriction, was the effect of alterations in estate programmes in connection with restriction, and the best methods of carrying out that restriction. Resting after pruning is one of those methods. Resting before pruning has been and is being carried out quite a lot in Ceylon; but I am not really in favour of it, except at very low elevations where carbohydrates are low. It seems to me that, in the high elevations if there is anything at all in the idea that you get better quality tea at the end of your cycle, to rest your bushes at the end of the cycle is definitely the wrong policy. Especially is this the case when you take into consideration the fact that, when you rest at the end of the cycle, you increase the wood growth of the bush, but you increase the wood growth on the very portions of the frame which you are going to cut out later when you prune. Surely it is better to rest after pruning and get all the benefits of that rest in wood growth on the new wood that is coming on after the pruning. I definitely suggest that, wherever possible, resting before pruning at the higher elevations in Ceylon should be abandoned in favour of resting after pruning.

The bringing in of the tea after pruning is quite simple. With tipping knives you go across at about the same level at which the bush would have arrived had it been plucked. A lot of people say that a second pruning is a second shock to the bush. All I can say is that my investigations do not confirm that idea in any way. You have rested the bush. You might say the same of a man who goes away for a holiday and has to come back to work again. It is no more of a shock, I think, to bring a bush in after resting. He has benefited by his holiday and will be able to work better afterwards. That, I consider, is what you will find with your tea bushes, and it is certainly what our results are showing. Incidentally, the results I am giving you are all from work carried out under field conditions.

Another point which demanded investigation was the effect of the length of the plucking round. Some people advocate a long plucking round, taking the tip of a long shoot and throwing the

rest away. Others advocate a short round, going round frequently. The results to date show that a seven-day round gives definitely more yield than a fourteen-day round, and that the teas made from it cannot be distinguished in value by the brokers from teas made after a fourteen-day round.

It, therefore, appears that neither the advocate of a short round nor the advocate of a long round can really claim to be supported by my results. They appear to be quite equal as regards the factors which affect the broker in giving a valuation. I have taken that valuation because it seems to be the best all-round measure of the tea It, therefore, appears that the long plucking round has the advantage in restricting your crop, but the shorter round is advantageous for increasing crop. Only experience on the estate will show whether the shorter round will show such an increase of crop as to justify the extra cost.

In addition to such things as these, a large number of investigations have been carried out on various subjects which have arisen very largely directly from planters' queries and troubles. We are always on the lookout. We get a query which sometimes we are able to deal with straight away, but sometimes we do not know, and we have adopted the policy of saying definitely that we do not know. I must say that this attitude is thoroughly appreciated, and planters have been content to wait until we had time to investigate the question.

Manganese toxicity, for instance, came up before the Agricultural Chemist, Mr. Eden. I went on with parallel investigations. We found that an excess of manganese in a nutritive solution gave rise to toxic conditions in young seedlings. Other matters of investigation have been the distribution of branches of flush within the bush, the processes involved in wound-healing in pruning and the effect of resting on the wood growth, the result of which, as I have shown, was to indicate that resting after pruning will greatly increase the wood growth of the bush. That is on all fours with such crops as apples in England. Investigations have also been carried out on the effect of elevation, and the time and type of pruning, on the size

of the flush brought in by the coolie — all things which link up with manufacture. As you see, in these minor problems my department is linked up with other departments of the Institute, just as they link up with me on other problems. In the T.R.I. problems are not kept in watertight compartments. For instance, Mr. Eden and I, being more particularly interested in the agricultural side of things, are constantly in consultation, I with regard to his work, and he in regard to mine.

As I said before, the main line upon which my investigations were to lie concerned the problems arising out of pruning and the various troubles which arise with the tea bush after pruning. I am not going to describe the scientific experiments we made. It would be out of place here, but I will just run through the results.

TYPES OF PRUNING.

Dealing first with the effects of the type of pruning, I have here photographs of three types: (1) clean pruning; (2) rim-lung pruning; and (3) cut-across. As I am talking about them you might like to see these photographs, which will enable you to follow what I am saying. Those three types of pruning — clean pruning, rim-lung, and cut-across — describe themselves. The cut-across is just a clean cut across the bush, taking out nothing (except diseased wood) below the surface. The rim-lung has branches — six in my experiments — left standing up above the level of the rest of the bush until the time of tipping. In other words, leaves are left on the bush during the recovery period. The third system results in no leaves being left on the bush, as you all know. That is an important thing. It means that a clean pruned bush has got to recover entirely by means of what is inside it. The carbohydrates — sugars and starches and such like — are manufactured by the leaves, and if, when you prune a bush, you take off all the leaves, all the new growth until leaves are produced has to come from reserves inside the bush.

I quite agree that in some cases growth comes on quite well, but it is by no means universal. For that reason I made an investigation of the reserves in the roots of the tea bush, and I have here

a graph* showing the results of my observations. It shows the percentages of carbohydrates in the roots of the tea bush plotted against elevations above sea level. As you will see, there is a linear relationship between the amount of carbohydrates in the root and the elevation above sea level. There are various scientific reasons for it, but what it comes down to is that, at low elevations above sea level, you have only about 10 per cent. of available carbohydrates in the root and the bush cannot make use of some of that reserve. When you get to the elevation of, say, Nuwara Eliya there is 25 or 26 per cent.

For an old bush to come back successfully after clean pruning, 10 per cent. is insufficient, and that is why those who are interested in estates at low elevations have to bear such heavy costs in the way of supplying tea; and I might also point out that you lose crop considerably even if the bush has sufficient carbohydrates to recover. At low elevations where there is just sufficient carbohydrates to enable the bush to come back after pruning, its crop is limited by its leaf area until something like one-and-a-half years after pruning; and if it is on a two year cycle, it means that it has only six months in which to lay down reserves before the next pruning. In other words, it is living a hand-to-mouth existence. Then comes a worse stage; a bush which has sufficient reserves to produce some new shoots, but not to recover normally. Where that occurs large portions of the frame will die back. I have had cases where I have collected more than 1,000 lbs. of dead wood per acre on an estate at two hundred feet, and that has been far exceeded in certain cases, even at higher elevations. At anything under 1,000 feet this may occur.

Again, you have the third and worst case, in which the bush fails to recover at all. The obvious answer to the problem is to provide the bush with some means of manufacturing those carbohydrates which it demands. To do so you leave branches unpruned at the time of pruning, and remove them later. This method has been found to reduce, in 1932, the number of deaths from 134 per acre in clean-pruned areas to 16 per acre in lung-pruned areas, and

* See T.R.I. Bulletin No. 12, Fig. 1 facing page 32.

in 1933 the number of deaths was reduced from 168 per acre in clean-pruned areas to 22 per acre in lung-pruned areas.

I do not know what you will estimate as the cost of replacing a mature tea bush, but I do not think you can do it under 50 cents. I put that figure forward as a conservative one to the Low-Country Planters' Association, and received no criticism of it whatsoever. Some people told me privately afterwards that they thought it might easily be more. Taking, then, 50 cents as the cost of replacing a dead bush, quite apart from the crop you have lost, it is going to cost you Rs. 59 per acre on the basis of the 1932 figures I have given you, or Rs. 74 per acre on the basis of the 1933 figures. Call it Rs. 60 per acre as a conservative estimate. The extra cost for lung pruning is going to be about Rs. 6 per acre. Surely it is worth that amount !

Then, again, apart from the replacement of absolutely dead bushes, what about those bushes which are half dead and which, for the greater part of the cycle, are struggling to regain activity, let alone to supply crop ? It has been found that lung pruning will reduce the amount of dead wood found after pruning from something in the neighbourhood of 700 lb. per acre in clean-pruned areas to 330 lb. in lung-pruned areas. That is another thing to add to your Rs. 60 per acre.

Now, let us see what it comes to in the way of crop. Experiments on this estate at 200 feet have shown that over two years there is a difference in yield, between clean-pruned and lung-pruned areas, of over 200 lb. per acre. In other words, it amounts to 100 lb. a year in a two-year cycle. It definitely looks as though the extra money spent on pruning therefore is going to be well worthy of consideration. In fact, I should say there is no longer any doubt left, and that no estate under 1,000 feet should on any account be clean pruned, but generous lung pruning with plenty of lungs should undoubtedly be adopted. On the basis of my experience I have come to the conclusion that below 1,500 feet you should lung prune; that from sea-level to 1,000 feet the number of leaves left on the bush should be something in the neighbourhood of 300 large leaves per bush; and from 1,000 to 1,500 feet you can reduce that number

to three branches with something in the neighbourhood of 200 leaves per bush, which should be sufficient. From 1,500 feet to 3,000 feet and upwards I advocate either light lung pruning or fringe pruning.

You will notice that fringe pruning means leaving unpruned all the branches on the outside of the bush. You prune to the level, but you do not remove those little whippy shoots. It has been the custom of Ceylon coolies to clean the bush up, and it led to very pretty looking work, but you can clean up the inside of the bush, taking out all the dead wood, and still be able to leave this fringe of young shoots to thicken up outside the bush. In the case of the lower levels, 1,500 to 3,000 feet, these leaves will be of great value in aiding recovery after pruning. In the case of higher levels — and I advocate it for anything from 1,500 feet to the highest levels in Ceylon — in areas where carbohydrate reserves in the root are high and you do not need leaves, I suggest leaving this fringe for a different reason entirely, namely, increase of the size of the bush. You are up against the fact that tea in Ceylon is an old crop, and was possibly planted in the early days in a rather different way to the way we would do it now. For one thing, I think a large part of it was planted too wide, and if you are going in for wide planting, which yet is not sufficiently wide to inter-plant, it means a low yield per acre. The only way to overcome that situation is to increase the size of the bush — to cover the ground more efficiently. It will react in many different ways. Quite apart from the extra yield which can be taken from the bigger bush, you have extra protection for the soil. There is less soil erosion, less deterioration of the soil by loss of humus, which is a problem of the utmost importance out there, and which probably is going to prove one of the main factors putting a limit to cultivation in the tropics: all these things would be rectified, partly at least, by increasing the size of the bush.

I have been told that these young fringe branches do nothing. I perfectly agree that possibly they do nothing for three or four cycles, but in time they will thicken out, and when they have thickened up and are pruned back they will begin to yield. Many of you will have seen, in the flesh or in photographs, big bushes on estates,

pet bushes. Many of those big bushes are got by letting the bush run up higher than normal. We do not want to run to that. What we want is a low bush, but with the maximum spread. To get it, it is going to be necessary to stop removing all these young spreading branches.

I cannot go into all these things fully now, but you will see them discussed in *The Tea Quarterly* for 1934, Parts I and II, where are reports of lectures I gave out there when these results first became available. I would point out that fringe pruning involves no additional cost. Inevitably, it costs more on the first field you do, because you alter the estate method, which appears to put up the costs for the time being because the coolies are not used to it; but actually when once they become used to it there is no reason why it should cost more than ordinary clean pruning.

I want to leave plenty of opportunity for you to ask questions, so I will not keep you much longer. This has been a rapid and brief account of some of the data and some of the results I have obtained, and the practical recommendations I have been able to make to your superintendents on that basis. But I would make this appeal. In certain cases our investigations have shown the way to reduction in costs. Take, for example, Mr. Eden's work on manuring. There is no doubt that he has shown a way in which manuring in Ceylon can be rationalised considerably, provided the green manuring policy is kept up adequately and how at the same time considerable financial savings can be effected.

That is the type of recommendation we like to give, naturally, but on other occasions, often more numerous, we are forced to recommend measures which are going to cost more. We have to deal with particularly difficult problems affecting tropical agriculture. I would put it to you that we are not scientists working in a test tube, oblivious to the rest of the world outside. We are looking at problems from the economic point of view, and we try to make sure that any recommendations we make are not uneconomic — that there is a fair prospect of the expenditure being more than returned in subsequent economic advantage.

When, therefore, you consider estimates involving some slight increase in cost — say, Rs. 4, Rs. 5, or Rs. 6 an acre — for pruning in the low-country, or measures for the increase of humus in the soil all over Ceylon, please believe that we have only recommended these measures because we are absolutely convinced that they are necessary for the future prosperity of your estates. (Applause).

The Chairman then invited questions, of which a number were asked and answered as summarised below.

MEMBERS' QUESTIONS

Q. Did Mr. Tubbs agree with an expert who lately wrote that the soils of Ceylon contained potash, which was used in manufacturing carbohydrates; and would it be possible to use potash to restore to the soil the potash of which it was gradually deprived by the growth of the bush?

A. So far as investigations have gone they confirmed the writer's statement, in relation to mangolds and other English crops, and there was no reason to suppose that the same did not hold good in regard to tea. Mr. Eden's experiments on manuring tended to confirm the idea that there were adequate reserves of potash in the Ceylon soil. It was found that no increase of crop followed the application of potash. Reserves of potash were naturally limited and considerable amounts were removed in the form of flush and especially in wood. It was because they were not going to risk running out of potash that they had never advocated omitting potash from manure mixtures, but suggested that it need not be supplied in large amounts.

Q. At what height was cutting across after resting advocated ? Experience showed the likelihood of the formation of snags when the cut went into red wood, leading to difficulty in obtaining good clean wood to prune into. Would it be better to have the pluckers go over the field and throw the leaf away so as to get a clean stem for the next pruning ?

A. It was not advocated that leaf should be thrown away after spending money to pluck it. It did harm to the bush. To have healthy bushes they should be rested, and if leaf were not wanted,

it should not be plucked. Snags arose from going into the red wood too low down. The cut should be at the height at which the bush would stand after normal plucking. To rest six months after pruning meant having eight or nine inches of good straight wood above the pruning level. In that case, when they pruned again there would be no danger of snag formation.

Q. What conclusions had been formed about the influence of manures on quality in Ceylon ?

A. Experiments had been made comparing the effects on tea of applying 0 lb., 20 lb. and 40 lb of nitrogen per acre, and the effects of potash had been examined in the same way. There had been no unanimity among brokers to indicate that any change of quality had followed. One difficulty seemed to be method. Tea tasting was essentially individual, and until the matter could be brought down to a fixed standard, judgment was very difficult.

Q. What was the result of investigation regarding the use of organic as against inorganic manures ?

A. There was no reason to suppose that any difference would arise. It might be postulated that an excess of nitrogen, producing rapid growth, might influence quality, but there was no reason to suppose that the form in which the nitrogen entered the soil influenced the quality of the tea produced. The form in which the nitrogen went into the soil had very little, if any, relation to the form in which it went into the bush, which was the important thing.

Q. In connection with nettle grub, tortrix, and other pests, had any experiments been made in Ceylon with spraying the bushes after pruning ?

A. The evidence available indicated that the hang-over from one season to another occurred on the leaf, and clean pruning would be the most efficient check to pests. It produced disorganisation of the estate system, however. Spraying reached only the outside of the mature bush, and the objection was the difficulty experienced in making the coolie do the work properly, because to reach the grub the spray must reach the under side of the leaf. Ordinary soap and

water was the best, but it was expensive, costing something like Rs. 16 per acre. Actually, nothing had been done on spraying pruned bushes as a check to nettle grub. It was the pruning which acted as a check.

Q. In Southern India, excellent results had been obtained by dry weather pruning. Would Mr. Tubbs give his views on the possibility of limiting the pruning to the dry weather period ?

A. It would be feasible in districts such as Uva, where there was prolonged dry weather, but the possibility of doing so on the other face of the Island was small, because pruning would have to be crammed into a couple of months, disorganising estate work.

Q. It was suggested that deterioration in the quality of Ceylon teas had been brought about by efforts to increase crops by manuring. By fine plucking quality could be improved. Was it not the case that if a certain proportion of carbohydrates could be allocated to the root and branch system of the tea bush, those constituents could be made to contribute to the quality of the leaf rather than to increase of the yield ? The excessive weight of Ceylon tea in the market was one of the causes why it was in its present state of depression.

A. Ceylon's future lay in maintaining quality as apart from quantity. The attitude of the Institute was that Ceylon was not interested solely in yield, but in quality. Their present knowledge of what went on inside the tea bush did not enable the question to be answered, however. Regarding the common association of poorer quality with manuring, much of the blame laid on manures really might be due to the fact that manuring increased yields faster than firms were able to increase their factory accommodation in the early days of manuring. It was being rapidly corrected, but some of the blame might be assigned to that cause. Increasing the manure to 40 lb. of nitrogen per acre had not affected quality in their experience. As to the compounds in the tea leaf influencing quality, no precise knowledge had yet been gained. It was under investigation, but presented a very difficult problem. Every superintendent in Ceylon had been in his factory night and day trying to improve it in recent

years. There was no lack of effort in that direction. On the whole, the standard of plucking had become considerably finer during the last year or two.

Q. Had the T. R. I. any theory about the influence of locality upon quality ?

A. They had been early forced to the conclusion that climate — both that in which the tea was grown and that in which it was manufactured — was a predominant factor in the production of quality teas. Environment was more important than the actual make-up of the bush. By environment he meant climate, soil, and all other things peculiar to the district in which the tea was grown.

Q. Sir Albert Howard had advanced closely reasoned arguments for altering the practice of forking green manures into the soil, which he maintained involved asking the soil in Ceylon to do a great deal too much. What were Mr. Tubbs' views ?

A. The Institute did not agree entirely with Sir Albert Howard, though they supported him in regard to the districts where his experiments had been carried out — where, on the farms themselves, there were special pits and everything right on the spot for making humus On such a basis humus could be made very cheaply, and cheaply carried to the field. But under the special conditions of growing tea in Ceylon, it could not be agreed that shifting green manure into pits or growing special growths was economic. It was a very expensive business to carry it to the fields in baskets in many places. For that reason the Institute had started a large experiment on this question. So far as they had gone the opinion was confirmed that it was purely the difficulties inherent in Ceylon which prevented the adoption of this method. For that reason it was better to dig the green manure into the soil *in situ*.

Q. The composting process which they had gone in for in Kenya had been favourably reported upon and might be valuable for Ceylon. Had the T. R. I. turned it down ?

A. There was a possibility — he would not call it a probability — that it would be useful, and it was not turned down. Once again, it was a question of recommending what was economic. The matter was being investigated, and no attempt was being made to give a final verdict until the results of experiment were available. At present all that could be said was that it appeared advisable to be cautious in applying this process, because of the cost. Under Sir Albert Howard's system they had to grow, on special areas apart from the tea crop, the material which was to be turned into compost, and this was a very practical and real difficulty in Ceylon.

No further questions being asked, the Chairman, in the name of those present, thanked Mr. Tubbs for his lecture; and the proceedings terminated.

A NOTE ON THE SUPPLY OF FIREWOOD FOR TEA ESTATES*

H. C. KING.

I. SILVICULTURE.

Compared with the subjects which have hitherto been discussed in *The Tea Quarterly* the organization of estate clearings for perpetual supplies of firewood is a simple matter which is familiar to the majority of readers. However, it will be generally admitted that a large area of the estate properties classified as firewood reserves or gum clearings is not being worked intensively to give the best financial results and one finds a wide divergence of opinion as to the object in view and the method of attaining it.

It is suggested in these notes.—

(1) that a definite loss occurs when accessible waste land is not worked at its maximum efficiency;

(2) that firewood can be more economically produced from a continuous supply of trees of small size;

* The Institute does not necessarily endorse the views expressed in papers contributed by persons not members of the staff.

(3) that firewood from young red gum if properly dried is equal in value to the firewood obtained from the mature trees

In conclusion, an attempt will be made to correlate the acreage of tea in bearing and the acreage of gum plantations which will meet the whole fuel requirements of the estate.

As regards the past history of fuel supplies very little has been published in the past; two pioneer planters made a valuable contribution to the study of exotic species but the question was not followed up and the results and species under trial have been lost sight of. It appears that between 1870 and 1875 two interesting plantations of exotics were formed at Pedro and on Abbotsford estate but records are not easy to trace at this stage and the identification of mature Eucalyptus without reference to herbarium material is difficult. An article in *The Tropical Agriculturist* dated 1895 shows that a species known at that time as *Eucalyptus pilularis* flourished on Carlabeck estate in Dimbula and that the proprietor of Pedro intended to plant his new clearings with it. *Eucalyptus* (*robusta* (?)) is stated to have been freely introduced on tea estates. In the same journal dated 1-9-02 the Himalayan Birch, *Betula acuminata*, with an edible bark, is recorded on Abbotsford estate together with *Eucalyptus pauciflora* and *E. ficifolia*; the firewood of *Eucalyptus globulus*, the Blue Gum, is condemned on account of a gummy deposit which occurred on the flues of tea driers. A correspondent in 1888 predicts a shortage of fuel for railway and estate supplies and discusses the desirability of forming fuel plantations for manufacture and for domestic use by estate labour; the proposal was unfortunately discouraged; it was observed that with labour at the rate of one cooly per acre, the annual acreage of prunings would provide sufficient twigs for the latter purpose and no serious effort was made to replace the jungle timber felled for estate and railway supplies

In *The Tropical Agriculturist* of 1-6-86 Mr. W. Twine gives a very sane appreciation of the question of fuel for tea estates. At that time coal was the only rival of firewood and he estimates, without giving details, as a fair average cost per pound of made tea

a figure of ·33 cent for firewood and 1 cent for coal; dealing further with a 300-acre tea estate he suggests that 2 acres of fuel should be made available annually on a 25-year rotation which we now know to be excessively long.

Abbotsford estate now contains very fine mature specimens of *Arancaria excelsa*, *Arancaria bidwillii*, *Syncarpia laurifolia*, *Betula acuminata*; and numerous *Bucklandia populaea* of moderate size. The Eucalyptus species could not be identified. On Balmoral estate, Agrapatana, *E. pilularis* has grown to very large size in 50-60 years. Many trees have been cut up for timber and one specimen still standing is over 13 feet in girth. *E. marginata* has also reached marketable size; one tree not very satisfactorily identified, being now 6 feet in girth and over 100 feet high. A complete survey of exotic trees on privately owned land with details of age, girth and height would be valuable.

For fuel supplies in clearings devoted to this purpose red gum answers well at any elevation over 2,000 feet. The ideal plantation is spaced 6 feet by 6 feet, grown from stumps or basket plants and is worked on a rotation of 12 years. At this spacing no thinning will be required and at the age of 12 years the species coppices readily from the stump and is very easily cut up into 3 feet lengths for transport and firing. The yield per acre on this system in a favourable locality should exceed 400 yards per acre and it may be emphasised that any deviation from this standard of 1,000-1,200 stems per acre involves definite loss of productivity and financial return. Where perpetual supplies of firewood are wanted it is inadvisable to grow large sized timber and smaller firewood in the same clearing. Timber can be grown on roadsides, in ravines, or in separate timber clearings without damage to the surrounding tea; softwood timber of immature Grevillea is in common use and if this species were allowed to reach its normal girth of 8 feet and upwards, the resulting timber would be much more durable; it appears to have a beneficial effect on the surrounding tea bushes, unlike Toona, Eucalyptus and Cupressus, all of which have disadvantages

in close association with tea. Trees in fuel plantations should if possible be felled in one smooth cut with a cross-cut saw about 1 foot from the ground, a method which is no more expensive than felling with the axe, but it has the advantage of reducing rot in the stump; further many estate plantations are subject to daily or nightly theft of poles and if all stumps are cut off smooth with a saw such offences committed with an axe or catty are much more easily detected.

On certain estates these questions have received full attention and separate clearings have been opened for firewood timber and for bamboos destined to be used in plucking baskets. It sometimes occurs that large sums are spent on liquid fuel on estates which have ample acreages capable of producing firewood; elsewhere, instead of 1,200 stems per acre or a minimum of 1,000 the stocking has been reduced to 200 per acre or even 20. The number of stems per acre is deceptive and difficult to estimate by the eye; the only real test is to measure a sample $\frac{1}{4}$ acre and count the stems. It is not possible to interplant seedlings in a middle aged plantation and all that can be done is to fell and interplant as early as possible, bringing the stocking per acre up to 1000; new seedlings can be interplanted among coppice stumps without disadvantage.

It might be argued that the firewood obtained from mature Red Gum over 30 years of age is more valuable than the softer firewood obtained at 12 years but this notion is disproved by recent investigations at the Tea Research Institute. Also the increased acreage required for a longer rotation makes it impossible to grow Red Gum for 30 years. The Tea Technologist has tested 4 samples of Red Gum, A about 6 years old 24 inches in girth; B about 15 years, $35\frac{1}{2}$ inches in girth; C 23 years old, $72\frac{1}{2}$ inches in girth; and the results are recorded in the annexed table; specimen D was 18 inches in girth taken at random from "dry" Red Gum firewood; the tests were carried out on the sawdust obtained from diameters of average length on cross sections 2 inches thick. It was hardly to be expected that four determinations would give tangible results but the agreement in column 6 is significant. One must conclude that the calorific value of Red Gum depends not on its age and girth

but solely on the thoroughness of the drying process before firing. This removes any doubt as to the advantage of a 12-year rotation designed to give the highest yield per acre; this yield naturally depends, not on the size of individual trees but on the number per acre and the size of the average tree.

TABLE I.

Specimen A	Girth @ 1 foot	Approx. age	Per cent. Moisture	Calorific value as felled (B.T.U's)	B.T.U's per lb. dry matter
Red Gum	24	6	48·2	4222	9157
Red Gum	35½	15	33·3	5870	9341
Red Gum	72½	23	48·0	4317	9299
Red Gum	18	—	16·2	7253	8860

It is probable that a fuel reservation equal to 10 per cent. of the acreage of tea in bearing is sufficient, but owing to such uncertain factors as the different rate of growth at various elevations and on exposed situations and the varying consumption of different types of dryers it is difficult to give approximate figures. Excluding any acreage reserved for scenic purposes, inaccessibility, or steepness, it is estimated that 50 acres of fully developed plantation should suffice for the entire firewood supply of an estate with 500 acres of tea in bearing, 35 for an area of 300 acres and 30 for an area of 200 acres in bearing.

If the area of reserved land is insufficient for a complete rotation of 12 annual clearings it may still be divided by 12 and the deficiency may be made up by liquid fuel. Or alternateively where an estate borders on Crown jungle the area can be increased by the lease and reafforestation of fuel blocks; there is no reasonable danger that these blocks will not be leased to the estate, at a higher rate, when they reach maturity, but their usefulness is reduced by the delay which seems inseparable from the demarcation and sale of these blocks.

In the case of an estate which has no land in reserve for fuel plantations it would be highly convenient to arrange a perpetual supply from shade trees felled in rotation in the tea. It would be a simple matter to divide the estate into 9, 12 or 15 sections for the felling and replanting of perhaps Grevillea on a sufficient scale to meet the whole annual requirements. However, there are very serious drawbacks to such proposals, (a) the damage caused to the frames of tea bushes by felling medium-sized trees all through the area, (b) the damage of fungal infection spreading to the tea bushes from the felled stumps of fuel-cum-shade trees; (c) there is the less serious disadvantage of excessive shade due to the large number of shade trees required per acre. As regards (a) the damage can be minimised by felling the trees immediately before pruning and by limiting the trees to the smallest size practicable; (b) will cause many people to dismiss the idea without further thought but the danger is known to vary with different districts, just as there is a marked difference in the rate of growth of Grevillea in Uva and in Dimbula. The suggestion is put forward tentatively for consideration on any estate in which a heavy shade of Grevillea is approved by the management. The substitution of Grevillea mulch for Dadap mulch may result is a loss of nitrogen in the soil but since the former is admirable in its physical properties, the deficiency can possibly be made good by artificial mixtures. For instance, on a 300-acre estate, assuming that Grevillea is fit to cut in 9 years and that the pruning cycle is 3 years, one might anticipate a yield of 1,000 yards per annum by felling the 9-year-old trees on 33 acres; these "mature" trees might be 18 inches to 20 inches in girth and there would be 100 per acre, also 100 per acre of 2 other age classes. Unfortunately no records are available to show the rate of growth in different districts but these can be readily collected if required. The following Table II shows 3 main blocks A, B & C pruned in rotation; block A would contain 100 trees per acre 9 years old; 100 six years old and 100 three years old, and so on. The fact remains that a very similar scheme has been operating for some years on a Dimbula estate, the species being the discredited *Acacia decurrens* which, however, causes no appreciable spread of fungal disease. If

the shade of 300 per acre of young Grevillea is considered excessive, the number per acre may be reduced and part of the fuel requirements met by liquid fuel.

TABLE II.

Block A, 100 acres	9	6	3 years.
Block B, 100 acres	8	5	2 years.
Block C, 100 acres	7	4	1 year.

GROUND COVER ON A DIMBULA ESTATE*

C. HUNTLEY-WILKINSON.

Since the article headed "Some Indigenous Weeds" appeared in *The Tea Quarterly*, 1933, Vol. VI, page 176, more experience has been gained and the following further notes may be of use to those who feel it would be beneficial to proprietary interests to arrest the soil denudation which continues annually. Before the dry period of the current year certain "Ground Covers" were established, mostly in exposed beds, on the same estate and were deliberately subjected to a severe test of not being watered except at rare intervals. I tabulate below the list of these with my observations on their utility.

Artemisia vulgaris.—This has survived the ordeal very well. Stringent measures are taken, however, to eradicate it from the tea area when it appears — not because I am convinced it is harmful, provided the ground is forked at frequent intervals, but because there is such great prejudice against it generally and there are so many more ground covers which to my mind are definitely harmless to tea.

Cardamine trichocarpa.—This has not survived the ordeal and I have therefore cut it out as a useful ground cover in Dimbula.

Cardamine hirsuta.—The same remarks applies here.

* The Institute does not necessariiy endorse the views expressed in papers contributed by persons not members of the staff.

Hedyotis monosperma.—This has barely survived but I have reason to think that it would do so if grown under tea.

Desmodium triflorum.—This has survived but the same remark applies to it as to *Artemisia vulgaris*.

Laurembergia wangerinii.—See remark under *Hedyotis monosperma.*

Biophytum proliferum.—This has done extremely well and it also affords a splendid cover in tea. Its roots are not deep seated. It is, however, not definitely self-establishing even if left alone by the weeders. A 13 acre field has been planted with roots of this. *Biophytum proliferum* is abundant in grass ravines.

Plantago lanceolata.—This is the ordinary lawn plantain and has very deep seated roots. It is not favoured for the same reason as *Artemisia vulgaris.* Foliage is actually non-existent in the bed in which it had established but I have reason to believe that it will shortly throw out new leaves.

Centrosema pubescens.—This has grown in abundance. It is not actually growing in the tea. The objection against it would be that it requires careful control to prevent its climbing up the bushes.

The larger *Desmodium* (with the purple flower) probably *D. Heterophyllum.*—This has done very well and promises to be an efficient ground cover but requires "introducing" which is a disadvantage.

Ranunculus wallichianus is very shallow rooted. It did not however survive the ordeal very well but is abundant at 4,000 feet under tea after the drought.

Centella asiatica.—Survived very well. The same remark applies here as that made about *Artemisia vulgaris.*

Cassia mimosoides.—A splendid ground cover and has survived well but requires actually introducing.

Cassia kleinii.—The same remark applies here as to *C. mimosoides.*

Triflorum subterraneum—is now practically non-existent and I do not fancy it is a perennial; in this case it will not be much use. I would make this same remark concerning most Clovers which require introducing and are not likely to last. The same remark applies to Lupins.

Justicia procumbens.—There is no doubt of the survival of this and it has done almost as well as *Biophytum proliferum* under the severe test. This is left to grow where existent in tea and it promises to spread rapidly. It has a small harmless fibrous root and could easily be eradicated at any time. There is a slight tendency for it to climb but control is easy. It is to be found throughout Dimbula in tea and has even been observed growing at Elephant Pass. If anyone wishes to establish a ground cover quickly, I would strongly recommend this plant. The nitrogen content of the leaves was determined at Peradeniya and is 0·72 per cent. which is slightly higher than that of sunflower.

Cassia leschenaultiana.—This was introduced from Java and has survived. It is apt to grow too high and continually loses its foliage.

Hydrocotyle javanica.—This has definitely died out.

Parochetus communis.—The same remark applies to this as to *Hydrocotyle*.

Torenia cyania, Alst.—The same remark applies here also.

Drymaria cordata.—This definitely defoliates, even under tea, in the dry weather.

The introduction of this as a ground cover is not recommended but I would certainly suggest its *control* where established rather than the spending of thousands of rupees in fruitless attempts to eradicate it. The more it is "pruned" with the weeding scraper, the more vigorous it becomes. It is one of the most efficient ground covers existent.

Oxalis latifolia and *Oxalis corymbosa*.—I do not think there is any further need to press the benefits of these as soil erosion preventatives except to repeat that no evidence was brought before the Soil Erosion Committee as to their doing any harm to tea.

Oxalis corniculata.—This has no bulbs. It is not to my mind prolific enough in growth.

Indigofera endecaphylla.—This is not too easy to establish in Dimbula but certainly has its advantages if persisted with.

It is needless to remark that many of the above are not actually legumes. If an actual indigenous legume can be found it would be very attractive, but I feel that the line of least resistance is the one to take in establishing a ground cover and, after all, many of the above which I have advocated as easy to establish have a very fair nitrogen content in their foliage.

Frequent forking and disturbance should counter any deleterious carpeting tendencies in ground covers.

If anyone is still doubtful of the existence of soil movement I would suggest that he plant *Paspalum dilatatum* soil barriers on what appears to be level ground and note after four months' heavy rains how quite a perceptible step is formed. On steep paths these barriers form very definite steps.

The Institute has laid down the axiom that soil erosion can only be efficiently checked *in situ* and that other useful control measures are little more than "a second line of defence".

HALF-YEARLY REPORT OF THE SMALL-HOLDINGS OFFICER, GAMPOLA

JANUARY—JUNE, 1935.

LECTURES AND MEETINGS

During the period under review three meetings of small-holders were held, one at Harispattuwa and two in the Baddegama area, where the new officer, Mr. Kannangara, has started work on the small-holdings. All three meetings were well attended, there being over 100 small-holders at each meeting. At these meetings the small-holder is advised as to the usefulness of cultivating green manures, adopting the new type of lock-and-step drain and the rim-lung prune, and doing more systematic work on his holding for its improvement.

DEMONSTRATION WORK

These meetings are followed by visits to small-holdings. During these visits every possible assistance is rendered to the small-holder in the carrying out of the new methods of cultivation, pruning, draining, etc These individual visits help further in enabling one to make suggestions to the small-holders whereby they overcome their particular difficulties. The opportunity is taken to discuss the various questions of cultivation and thus learn more about their work.

VILLAGES VISITED AND REVISITED

The villages visited have all been in Uda-Palata in the Central Province, mainly due to a competition organised by the Divisional Agricultural Association of Uda-Palata for which cash prizes have been offered by the Institute. The object was to encourage the small-holders to further efforts.

Ninety-four small-holdings have been visited and inspected and the owners of these holdings have been carefully instructed on the methods of cultivation, draining and pruning as advocated by the Institute.

These ninety-four small-holdings are situated in 21 villages, where 23 demonstrations in pruning and draining were carried out.

The rim-lung prune and the lock-and-step drain were those demonstrated. The usefulness of cultivating green manures was also emphasised at these demonstrations.

GENERAL

The general progress on small-holdings during the period under review has been very little. This I attribute mainly to two causes, the prolonged drought and the malaria epidemic. Tea restriction is also in a small measure responsible for the neglect.

SMALL-HOLDINGS COMPETITION

It is unfortunate that this competition may have to be postponed owing to the malaria epidemic and the unfavourable weather conditions, which prevented the necessary works being done on holdings.

MALARIA EPIDEMIC

The epidemic which started in my area in November last year still continues and today it is worse than what it was ever before.

The Institute very generously made my services available for malaria relief work which I did during January and February, resuming regular work in March.

I was in the Baddegama area with the newly-appointed officer during the latter part of June, attending meetings among the small-holders and meeting some of the district planters. There were, I noticed on my visits, a few small-holders who had already taken to the new methods of draining and pruning. The meetings were well attended and those present were quite interested to hear of the new methods.

There was also, I noticed, ready co-operation from the district planters and I think the conditions of the small-holdings and small-holder will be greatly improved with this new work, which has already been started.

In conclusion, I must thank all those who have rendered me assistance and willing co-operation in my work.

R. L. ILLANKOON,
Small-Holdings Officer,
Gampola.

HALF-YEARLY REPORT OF THE SMALL-HOLDINGS OFFICER, BADDEGAMA

Small-Holdings Officer	...	E. F. Kannangara.
Appointed	...	1st March, 1935.
Assumed duties at Baddegama	...	24th March, 1935.
Number of Small-Holdings (10 *Acres and below*)		*Galle & Matara Districts* 4,298 *Hambantota District* Nil.
Rainfall in Baddegama Area	...	1934 .. 157·90 inches. 1935 to date 58·73 ,,

OWNERSHIP

In the two tea growing districts the small-holdings are owned by people resident in the districts. Very few holdings have been leased out.

GENERAL CONDITIONS

These vary in the different Chief Headmen's Divisions. In the Galle District the best holdings are found in Gangaboda Pattu. The soil in this area is very suitable for tea cultivation but unfortunately it is only now that proper attention is being paid. Owing to the very depressed state of the finances during the last 3 or 4 years the conditions appear to be very poor. In Bentota-Walalawiti Korale there are a few holdings towards Elpitiya which are in a poor state of growth. Wellaboda Pattu, Talpe Pattu and Four Gravets have a fair number of holdings which are maintained fairly satisfactorily.

DETAILS OF MAINTENANCE AND PLANTING

The best jât has not found its way into very many small-holdings. Medium quality jât has been used in nearly 75 per cent. of the holdings.

SOIL EROSION

No steps whatever have been taken to plant any cover crops to conserve the soil. The old system of drains has been adopted by almost all the holders following the example of adjoining estates,

The best top soil has found its way to the low-lying area. This process of erosion has not only depleted the fertility of the tea holdings but has done considerable damage to the paddy field owners. No sudden change can be expected from the hands of the small-holders except through wide and earnest propaganda given to them free of cost at their very doors.

SUPPLY

There are large number of vacancies in most of the holdings in this area. With the adoption of improved systems of cultivation it is very necessary to ensure the owners a good supply of the best jât tea plants, which can only be done by opening a nursery of seed bearers in a plot of about ten acres within the district. By this gradual process of supplying the best jât, the main object of establishing good yielding areas with good flavoured tea can be attained.

GREEN MANURE

Gliricidia and *Albizzia* being available from the large estates have found their way to almost all the small-holdings, but it is deplorable that bush types of green manure plants which give good results have not taken the fancy of the small-holders who evidently do not know the value of these.

PRUNING

As regards pruning, until it was demonstrated to the holders, the old system of giving a drastic pruning was adopted throughout. Of recent date the value of the rim-lung system seems to be appreciated and adopted.

WEEDING

This has not been carried out regularly by the small-holders. Once in two or three months the holdings are weeded by some, while a very small percentage of the holders do their regular round of weeding.

SUMMARY

To attain better conditions of the holdings it is necessary to give the benefit of all literature published on tea to the small-holders by making this available through propaganda conducted in Sinhalese,

RESTRICTION

This has brought relief to owners of small-holders whose position has been precarious before the restriction. Roughly 80 per cent. of the holders are at present selling their coupons. The money is being utilised for various purposes. The Tea Control Department issues coupons quarterly. This has resulted in the small-holders having accounts opened with various traders and money lenders to meet their intermittent demands, such as provisions, including rice and currystuffs, and small cash loans, etc. On receipt of the coupons the owners are entirely at the mercy of the trader who gets the coupons endorsed into his hands and gives credit only as he wants, thereby depriving the owners of the full value of the coupons. It is regrettable that once the coupons are in the hands of the holders they do not think of the source from which they came to possess them. Coupons are generally surrendered to the traders or sold in Galle. In some cases estate owners are themselves buying to augment their supply. There are also a number of hawkers who are visiting the post offices during the dates of issue and are buying the coupons on the spot. The prices paid are three to four cents less than the Colombo market price. It is only in rare cases that a portion of the money got by the sale of coupons is spent in maintaining the holdings properly. I have found a small percentage of holders do plucking and sell their green leaf as uncouponed tea to factories. The present rate of payment in this district is two cents per pound of green leaf.

The holdings are not properly worked owing to their being no proper market for green leaf once separated from the coupons. The villager as usual, being an easy-going individual who wishes to have the best benefit with the least energy, sells the coupons and neglects his small-holdings.

BOUGHT LEAF FACTORIES

There are no factories entirely for bought leaf in this district. This is a great difference from up-country areas. All the factories that were in existence before restriction are normally working now. There has been an addition of one factory since restriction.

WORKING METHODS ADOPTED BY ME

I assumed duties in the Southern Province towards the end of March. My first step was to induce all the headmen, estate owners and planters to take an interest in the propaganda work with which I am entrusted. In pursuance of this object I attended several division days convened by the chief headman and addressed the minor headmen on the importance of looking after the interest of the small-holders who have at present no one to look up to for advice and guidance.

Through the medium of the Southern Province Planters' Association, the meetings of which I attend having been elected a member, I have come in touch with all the planters, superintendents of estates and their assistants. The response shown by the major planting community has been very satisfactory. I take this opportunity to thank the planters for the very ready manner in which they are co-operating in my work.

MEETINGS AND DEMONSTRATIONS

I pay regular visits to different villages to give demonstrations in rim-lung pruning and cutting of lock-and-step drains. I have held several small-holders' meetings at which the Chairman of the Planters' Association, Southern Province, presided. I explained to those who were present at these meetings the different methods advocated by the Tea Research Institute. I have also arranged a meeting of all the members of Co-operative Societies of the Southern Province to be held at St. Aloysius' College, Galle. At this meeting I will be delivering a lecture on "The best methods to adopt to improve the tea small-holdings.

CO-OPERATIVE SOCIETIES

Another direct channel of propaganda is provided by the various Co-operative Societies numbering 40 in Gangaboda Pattu alone I have attended several meetings of these societies and from my observations it appears to me that the majority of the members are tea small-holders, hence in this way useful propaganda can be carried out.

WORKING OF SMALL-HOLDINGS

Galle district has a good network of roads and in the first instance I have selected several plots situated by the main roads to demonstrate the methods advocated by the Tea Research Institute. This will give the maximum benefit at the start as all travelling along these roads can avail themselves of the opportunity of seeing the new methods at minimum cost and expense. So far I am glad to state that the response and co-operation given by the small-holders have been beyond my expectation.

E. F. KANNANGARA,
Small-Holdings Officer,
Baddegama.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 15-3-1935.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held in the Ceylon Chamber of Commerce Rooms, Colombo, on Friday, the 15th March, 1935, at 10-30 a.m.

Present.—Mr. James Forbes (Jnr.) (Chairman), the Hon'ble the Financial Secretary, Col. T. G. Jayewardene, V.D., M.S.C., Major J. W. Oldfield, C.M.G., O.B.E., M.C., Messrs. I. L. Cameron, R. G. Coombe, R. P. Gaddum, C. E. Hawes, J. D. Hoare, D. H. Kotalawala, M.S.C., A. W. L. Turner (Secretary), S. C. Bisset (Accountant) and by invitation Dr. Roland V. Norris (Director, T.R.I.) and Mr. J. W. Ferguson (Visiting Agent).

Absent.—The Director of Agriculture and Mr. D. T. Richards.

1. Notice calling the meeting was read.

2. The Minutes of the meeting of the Board of the Tea Research Institute of Ceylon, held on the 11th December, 1934, were confirmed.

3. T.R.I. BOARD

The Chairman extended a welcome to Mr. R. P. Gaddum, the new Chairman of the Planters' Association of Ceylon, and Major J. W. Oldfield, who had returned from furlough.

Mr. B. M. Selwyn, the late Chairman of the Planters' Association of Ceylon was thanked for his services whilst a member of the Board.

The Chairman also pointed out that this would be Mr. Hawes' last Meeting before he went on leave, and thanked him for his valued services whilst he had been Chairman of the Ceylon Estates Proprietary Association.

Announced that the following members had been nominated for a further period of three years as from the 1st January, 1935:—

Mr. R. G. Coombe representing the Planters' Association of Ceylon.

Major J. W. Oldfield representing the Ceylon Estates Proprietary Association.

Mr. D. H. Kotalawala, M.S.C., representing the Small-Holders (Nominated by H. E. the Governor).

(a) *Acting Chairman.*—The Board approved of the nomination of Mr. R. G. Coombe as Acting Chairman during the absence of Mr. James Forbes (Jnr.) from the 3rd April to the 8th May, 1935, when Mr. James Forbes (Jnr.) will be in Java with the Director.

4. FINANCE

(b) *Finance Sub-Committee.*—Major J. W. Oldfield resumed his seat on the Finance Sub-Committee *vice* Mr. J. C. Kelly, who had been acting for him.

(c) *Medical Sub-Committee.*—Major J. W. Oldfield was appointed to this Sub-Committee *vice* Mr. J. C. Kelly resigned.

Audited Accounts.—The Chairman informed the Members that the Audited Accounts and Report for 1934 and the Statement of Accounts for January, 1935, had been discussed at the Finance Sub-Committee Meeting held that morning.

The Audited Accounts for 1934 and the Statement of Accounts for January, 1935, were approved.

5. SENIOR STAFF T. R. I.

(a) *Entomologist — Mr. C. B. R. King.*—Announced that this officer had resumed his duties on the 28th January, 1935.

(b) *Plant Physiologist — Mr. F. R. Tubbs.*—The Director informed the meeting that Mr. Tubbs had given a very successful lecture to the members of the Ceylon Association in London dealing with the work of his section.

Mr. Hoare asked if copies of Mr. Tubbs' lecture were available.

The Chairman replied that copies of the lecture would be published in *The Tea Quarterly*.

6. ST. COOMBS ESTATE

(a) *Superintendent.*—The Chairman announced that Mr. John A. Rogers had returned from furlough on the 18th January, and had resumed duties on that date relieving Mr. E. J. K. Garthwaite, who had been acting for him.

(b) *Visiting Agent's Report.*—There were no comments on the Report of the Visiting Agent, a copy of which had been sent to each member of the Board under cover of Circular No. A. 1/35, dated the 21st January, 1935.

The Chairman informed the Board that that would be the last meeting at which Mr. Ferguson would be present prior to his departure on leave on the 3rd April. A vote of thanks to Mr. Ferguson was recorded for his services in visiting the estate and for his willingness to give advice.

(c) *Acting Visiting Agent.*—Announced that during Mr. Ferguson's absence on leave, Mr. J. E. B. Baillie-Hamilton had agreed to act.

(d) *Estate School.*—This subject had been discussed at the last meeting and the superintendent had now advised the Chairman that the school had been inspected. It was hoped that the school would be registered shortly.

7. EXPERIMENTAL SUB-COMMITTEE

A copy of the minutes of the last meeting of the Experimental Sub-Committee had been sent to each member of the Board on the 7th March.

8. WATER AND ELECTRICTY TO KADDY

The Board approved of the installation of electric light and water to the caddy at present leased to Mr. M. S. Salgado at his own expense.

9. SECRETARY'S LEAVE

The Chairman informed the Board that the Secretary, Mr. A. W. L. Turner was proceeding on leave as from the 20th March to the 20th November, 1935, and thanked Mr Turner for the services he had rendered to the Institute and wished him *Bon Voyage*.

10. ANNUAL REPORT FOR 1934 ON ST. COOMBS

The Secretary's portion of the Ninth Annual Report of the Institute had been sent to each member of the Board under cover of Circular No. A. 3/35, dated the 2nd February.

11. T. R. I. CONFERENCE

The Chairman reported that the Fourth Conference of the Institute had been held on the 1st and 2nd March at St. Coombs.

The meeting terminated with a vote of thanks to the Chair.

STANLEY C. BISSET,
Secretary.

NOTICES.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

Publications.—Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not to the Director's Office.*

ROLAND V. NORRIS,
Director.

EDITORIAL.

FOREIGN MATTER IN TEA.

Numerous complaints have been received in recent months, particularly from America, in regard to foreign matter in tea, and it is most desirable that estates should take steps to eliminate any possibility of such contamination.

The list of articles reported as found in tea is a comprehensive one, and it is difficult to understand how the majority of these fail to be removed during grading and picking over. It is obvious, however, that this does happen and that further precautions are required.

The simplest and most effective method of elimination would probably be the use of some kind of hopper sieve over the packing machine, so that all the tea would receive a final screening immediately before packing. We understand that an inexpensive apparatus of this kind has been devised on Ottery estate, and is at present under trial. Care will, of course, be necessary that the final grading is not altered, nor the tea greyed, by the use of such an appliance.

These points are receiving attention, and it is likely that a satisfactory machine will soon be available on the market.

COMPOSTS.

The subject of composting, and in particular the use of the Indore method, continues to arouse much interest. The attention of our readers is therefore invited to the report in this issue of a discussion on this question which took place at a meeting of the Standing Committee of Agriculture of the Planters' Association of Ceylon held on September 20th.

From this report the attitude of the Institute should be quite clear. The point at issue is not the merit of the Indore method which is universally recognised, but simply whether, *under the conditions which exist on the average Ceylon estate*, composting is an economic proposition.

In certain areas of southern India, and also in other countries, compost has been produced by the Indore process at such a low cost that there can be little or no question as to its profitable utilisation.

In contrast to the conditions found in these countries, the majority of Ceylon tea estates are faced with the following difficulties :—

(1) Areas in the neighbourhood of estates from which waste material can be obtained are limited, or non-existent.

(2) There is not the surplus of male labour which has contributed materially to the low cost of compost in Travancore.

(3) Transport facilities on estates are usually poor.

In consequence of (1) most estates have had to use a very considerable amount of green manures, already growing in the tea, as composting material. The amount of *new* material brought to the field in the finished compost is thereby greatly reduced. In consequence, the relatively high cost of compost, which cannot be avoided under our conditions, renders its economic use much more problematical.

Details of such costs are given in Dr. Eden's memorandum, and should make it sufficiently clear that the continual stress laid on the low costs of compost in other countries, where totally different conditions prevail, has little bearing on the question as it applies to Ceylon.

It is unfortunate that, through some lack of appreciation of the existing difficulties, the question of composting should have become a matter of controversy. The fundamental idea underlying the use of composts, namely the desirability of increasing the reserves of organic matter in tea soils, is one on which there is no difference of opinion. The manner in which this can most economically be achieved is, however, a question which may be solved in different ways according to local conditions.

SMALL-HOLDINGS COMPETITION.

In collaboration with the local Agricultural Association, the Institute initiated a year ago a competition for small-holders in the Uda Palata Division. Three prizes were offered in each of the four Korales of this Division for the best worked holdings, special attention being paid to drainage, pruning, plucking, provision of green manures and shade, and soil conservation. Competitors were required to register their names at the commencement of the competition, and their holdings have been inspected at frequent intervals during the year in which the competition has been in progress in order to examine the progress made.

The total number of competitors was 176. A preliminary judging by the Institute's Small-holdings Officer, carried out a month before the end of the competition, reduced this number to a short list of 54, and the latter have now been judged by the Director in collaboration with gentlemen nominated by the Divisional Agricultural Association. In this connexion we would express our deep obligation to the gentlemen concerned, Messrs J. Benzie, C. A. Paul, and W. F. Stephen, for the time and trouble they devoted to this work. We would also thank Mr. M. H. Reeves and Mr. W. Wijesekera for the interest they showed in the competition by accompanying the judges on part of their inspections.

The holdings inspected varied in size from ½ to 8 acres, and it is satisfactory to record that much excellent work had been carried out. This is the more to be commended in view of the fact that the area in question had suffered badly in the recent malaria epidemic.

The most noteworthy feature was the attention paid to drains. Most of the holders had cut reverse-slope drains, and the edges of these were frequently stoned and protected by paspalum margins. The holdings were clean and a good deal had been done to provide green manures and shade by the planting of gliricidias, dadaps and acacias. Climatic conditions had militated against the establishment of cover crops though efforts had been made in many cases to put these down. Pruning and plucking were perhaps the least

satisfactory features. In plucking especially, few holders had been able to resist the temptation, provided by the recent rise in the price paid for bought leaf, to strip their bushes.

The general condition of the holdings inspected was, however, a pleasant surprise, and a tribute both to the good work put in by the Small-holdings Officer, and to the keenness and enterprise of the small-holders concerned.

The final result of the competition was as follows:—

			Size of Holding.
Ganga Thala Korale.			
1st Prize, Rs. 25	R. Kira	P. P. Lot 128	2 acres
2nd Prize, Rs. 15	K. M. Kiri Banda	Malliyatenne	8½ ,,
3rd Prize, Rs. 10	Simon Reyal	P. P. Lot 52-K	1½ ,,
Commended	K. S. Vellaswamy	Kandegederawatte	4½ ,,
Ganga Pahala Korale			
1st Prize, Rs. 25	K. M. Ukku Banda	Katuliyadde	3½ acres
2nd Prize, Rs. 15	H. M. Appuhamy	Meeginiwellawatte	1½ ,,
3rd Prize, Rs. 10	L. M. Ekanayake Appuhamy	Bundunewatte	2½ ,,
Commended	G. K. Sandara	Ratenubewatte	2 ,,
Kandukara Pahala Korale			
1st Prize, Rs. 25	T. P. R. Manic Rala	Boolamadahena	2½ acres
2nd Prize, Rs. 15	W. J. de Silva	Pillawe-watte	8 ,,
3rd Prize, Rs. 10	W. Moona H. Lebbe	Kotte Walawwe Watte	½ acre
Extra Prize, Rs. 10	H. M. Punchi Banda	Polgahamulle Watte	½ ,,
Commended	G. M. S. de Silva	Wallegedera Tanue	3 acres
	A. W. A. Rambanda	Galkatte Watte	½ acre
Kandukara Thala Korale			
1st Prize, Rs. 25	K. M. Appuhamy	Wellegode Hena	7 acres
2nd Prize, Rs. 15	A. G. Siyatu	Mudune Watte	1 acre
3rd Prize, Rs. 10	M. I. R. Dharmasena	Devale Ela	2 acres
Commended	D. B. Goonesekera	Kapuruduntanne	½ acre
	G. Liyanora	Ganade Watte	2 acres

The conduct of the competition, as indeed the general work of the Small-holdings Officer, has been much facilitated by the assistance and support given by the Ratemahatmaya, Uda Palata, and the various headmen throughout the area, to all of whom we tender our cordial thanks. Our thanks are also due to the members of the Divisional Agricultural Association for their collaboration.

ROLAND V. NORRIS,

ORGANIC AND INORGANIC MANURES.*

T. EDEN.

The address which I propose to give you to-day in response to your Chairman's invitation to me to speak on organic and inorganic manures, is not quite the same as it would have been if your meeting had taken place a week earlier. In common with most of you, I expect, when I opened the daily paper the other day, I turned my attention first to the article on Manuring of Tea. As a result of the publication of this article at this particular juncture, I have decided not to traverse essentially similar ground by giving you full experimental details of our own trials on the same subject, but to broaden the basis of my remarks so as to deal with some of the fundamental questions that such experiments provoke, and to use the experiments as illustrations.

If we are to survey the whole field of organic and inorganic manuring we shall have to divide our manures into four classes:—

(1) Inorganic artificials.
(2) Organic artificials.
(3) Green Manures.
(4) Bulk manures, including composts.

and we may well start by considering some of the essential differences between these types.

There should be no ambiguity as to what is meant by an inorganic artificial. It is a material made either synthetically or derived from mined deposits which are not derived directly from animal or vegetable material. Nitrate of soda, sulphate of ammonia, cyanamide, potash salts, and rock phosphate derivatives fall naturally into this class. Organic artificials are taken to include the residues from plants or animals, such as oil cakes or animal offals, and are familiar to you in terms of groundnut cake, whale and fish guano and bloodmeal. Green manures need no definition.

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* Address given to the Sabaragamuwa Planters' Association on 26th July, 1935.

Bulk manures and composts are essentially vegetable material with or without animal excreta that have undergone a process of fermentation. I have indulged in this elementary exposition, because in what I have to say later I want there to be no confusion as to what type of material I am describing.

We can separate these types into various classes. First we can divide them roughly into soluble and insoluble manures, putting class I by itself as soluble. But even amongst inorganic artificials a distinction must be made. Suppose we consider nitrate of soda, sulphate of ammonia and muriate of potash. Ordinarily speaking, these are all highly soluble materials, but in the soil they behave differently. In nitrate of soda it is the nitrate portion that interests us, and it is correct to regard this nitrate as readily soluble and easily leached away. With sulphate of ammonia the ammonia portion is what we want, and with nitrate of potash, the potash is the important part. Now, soil has the power of removing from solution these important parts of the manure and of fixing them. An experiment to show that this is the case is very easily contrived, and I have frequently demonstrated it to visitors at St. Coombs. Sufficient to say at the moment, that a so-called soluble manure does not necessarily behave as such in the soil immediately. Let us put it as a conundrum. When is a soluble manure not soluble? The answer is when it is an ammonium or potash salt.

We can also separate these groups according to a further criterion, particularly with respect to the behaviour of their nitrogen. Which are readily available and which less so?

It is admitted on all sides that the compounds of nitrogen which a growing plant can directly use are fairly simple. The old text-book notion that every form of nitrogen must ultimately be changed to nitrate before it can be absorbed by the plant, is now known to be fallible, but the classes we have been considering do vary most markedly in the complexity of their nitrogenous compounds. The main step in arriving at this complexity is when the nitrogen is chemically combined with carbon as is the case with organic artificials, green manures and bulk manures. At first sight

therefore it looks as if organic nitrogenous manures should be classified as markedly less readily available than inorganic nitrogenous manures.

Actually it is not quite as simple as that. To a large extent the rate at which a complex compound will break down to a readily available one is determined by the proportion of carbon to nitrogen in it, and in our chemical jargon we frequently talk about the carbon nitrogen ratio. I will not mystify you with a digression on this subject, but will give you a rough working rule. Usually an organic substance containing more than two per cent of nitrogen will easily furnish available nitrogen, and the higher the percentage of nitrogen the more readily available it will become. From this it follows that inorganic artificials and organic artificials with percentages varying from four to twelve and a half, readily supply nitrogen usable by the plant, and may be classed together. Dr. Joachim's experiments confirm this classification in work he has carried out at Peradeniya.

On the other hand, green manures, bulk manures and composts may have quite a lot of nitrogen in them that is only slowly available.

We can now turn to another detail and that is the difference between green manures and bulk manures and composts. The availability of green manures will depend largely on their having a suitable carbon nitrogen ratio when dug in. The other two materials are usually made from products where the carbon nitrogen ratio is too high for immediate use, but the fermentation processes in manufacture modify the ratio in the direction of increased availability.

A further point of view is that of the effect of these manures on tilth or the physical state of the soil. In so far as the addition of organic matter is the cause, then bulk manures stand in a class apart. The few hundreds of pounds of organic material contributed by an organic artificial to the $2\frac{1}{2}$ million pounds which represents the weight of soil to a depth of nine inches over an acre, is a mere drop in a bucket. It may be of interest here to say that so far as tea is concerned, sulphate of ammonia preserves tilth, but continuous use of nitrate of soda in large quantities destroys it.

Reviewing now our classification of manures, it is evident that on all counts organic artificials resemble inorganic artificials more than they do the bulk manures, composts and green manures. Without further examination, therefore, we cannot claim for organic artificials all the virtues which are known to accompany the use of bulk organic manures.

So far we have been examining the properties of manures mainly from the point of view of information gathered from the chemical laboratory. Let us see how far field results tally with them. Here I shall restrict myself to the comparison of inorganic and organic artificial fertilisers. For the last four years the percentage increases or decreases in crop due to organics compared with inorganic sources of nitrogen are as follows :—

Percentage increase in yield due to organic manures compared with inorganics.

1931		1932	1933		1934		
—2·7	nil	—0·4	—4·4	—0·1	—-2·8	nil	—1·2
T.B.	B.	B.	B.	T.B.	T.G.	B.	G.

T refers to tippings ; B means that the comparison is between sulphate of ammonia and bloodmeal; G between sulphate of ammonia and groundnut cake.

All these small differences are well within the experimental error and the results indicate that so far there has been no difference in yield.

The diagram* I have displayed for your attention shows how the effect of these manures has been spread over three of the years under consideration. You will notice how closely the yield curves agree whether the actual level of production is high or low. The data are based on means of 12 plots in each case, six receiving nitrogen at the rate of 20 pounds per acre and six at 40 lbs. per acre. Such agreement as is here shown is obviously not a matter of pure chance. Evidently the data do not support the contention that nitrogen losses are greater with sulphate of ammonia than with organic manures such as those mentioned, nor do they confirm

*Not reproduced.

the view that organic manures because of their slower availability give a more even distribution of crop yield. As you will probably raise in discussion the question of increased yields from inorganic nitrogen as displayed in the diagrams published in the *Times* article, I may as well comment on them now. In trial No. 1 of that article the yields from inorganics appear to have surpassed that from organics by some thirty per cent or more, whilst in the second the increase is thirty-eight per cent. I am not disposed to accept, on the strength of single plots of large size, the conclusion that these differences represent adequately the difference in yield producing capacity of the two types of nitrogen. I think the explanation lies rather in initial fertility differences between the plots chosen.

One more point regarding availability. In my Annual Report for last year, copies of which you have probably received recently, you will find that I have drawn up a tentative balance sheet for recovery of nitrogen by tea. The amount recovered from manurial applications seems very low indeed, being only some 18 per cent for flush, foliage leaf and wood. What happens to the rest I can only conjecture at the moment. The point is that there appears to be no increase in efficiency of recovery of nitrogen on the part of organic artificials.

These results are only a part of the evidence relating to the behaviour of inorganic and organic artificials. I have recently had the opportunity of discussing with Mr. H. R. Cooper of the Indian Tea Association's Research Station, Tocklai, Assam, a similar series of experiments that has been running with unchanged manuring for ten years. These experiments have been interpreted by the same statistical criteria as we employ, that is, we are both making use of the same standards of accuracy. For the range of manures we use in Ceylon, the Tocklai results during this period supplement and confirm our own experience.

The question of quality effects in made tea is naturally of great importance. All our manurial experiments are manufactured and the teas reported on by a team of tasters. As far as is possible,

subject to the departure of members of the team on furlough, the team is kept constant. During the last year of the last pruning cycle, two tasters agreed in finding no difference between organic and inorganic nitrogen teas. The third picked out the bloodmeal tea for special favour, though that improvement was not given a price value. In the present cycle four tasters are up to the present giving a slight preference to inorganics. The taster with a flair for bloodmeal was unfortunately not available at the time when tasting of second pruning cycle teas was started, but arrangements have been made for him to receive the samples as heretofore. We are naturally anxious to give all treatments the fullest possible test, and we have recently arranged to obtain London reports, as well as those from Colombo, on a similar basis. As a matter of interest the Tocklai teas tasted by teams in Calcutta and London show no difference in quality between organic and inorganic manures.

I have been asked more than once recently whether organic manures contain any accessory foodstuff analogous to vitamins, or some growth promoting substance which will impart to them special properties. This may possibly be the case. At present one of the most exciting lines of chemical and plant physiological research in relation to agriculture is the search for growth promoting substances. Such substances have been found but their properties are not yet understood. A substance which promotes growth in the above ground portions may act as a growth restricting agent as regards the roots. These substances appear to occur both in animal and vegetable tissues, and we are not in a position yet to say whether they are generally necessary as additions to ordinary plant nutrients, or whether the plant ordinarily contains sufficient for all normal growth. In fact the things we don't know about them far exceed the things we do. But current opinion is disposed to think that green manuring offers a means of supplying or preserving these little known substances. I give you this information for what it is worth, because it seems to me that it is on these lines that any attempt to distinguish "inorganic" from "organic" manures must proceed.

The position then is that field trials have failed to show any differences between organic and inorganic nitrogenous manures, and that, as far as direct nutrition is concerned, that is in keeping with what we know of the chemistry of these substances. Any special growth promoting substances that may possibly be present are evidently not required until the general level of fertility has dropped below that of the experiments that have been quoted, and are just as likely to be provided in any case by adequate green manuring

DISEASES OF THE TEA BUSH—I.

DISEASES IN GENERAL AND FUNGI IN PARTICULAR

C. H. GADD.

The object of agriculture is the production of a commercial product of satisfactory quality and quantity, but the achievement of that objective is frustrated more frequently by disease than by faulty agricultural practice. A knowledge of plant diseases and the methods of their control are, therefore, as essential to the study of crop production as are such subjects as soil tillage and plant nutrition. Apart from such disastrous epidemics as those caused by the potato blight of 1845 in Ireland, the coffee leaf disease in Ceylon in the latter half of the 19th century, the chestnut tree blight in the United States of America which, since about 1906, has threatened to exterminate the American chestnut, the blister rust of white pine which has spread to an alarming extent through the north-eastern United States, and banana wilt which has seriously threatened the banana industry in several countries, the annual loss from plant diseases throughout the world is immeasurable. Russell* has estimated that in Great Britain alone "it is probably at least 10 per cent of the total value of the crops, and the loss is probably some £12,000,000 sterling per annum".

*Presidential Address, British Association, Section M, 1924.

No very strict definition can be given of the word disease, but in its broadest sense it implies any departure from a state of health, in which each organ fully performs its normal functions. In plants, a derangement of the physiological activities of an organ is usually accompanied by structural changes or the premature death of a part or of the whole plant. Usually there is no difficulty in recognising the existence of disease, though its causation may be obscure. Rational means of control, however, can only arise after the cause is known.

Plant diseases can be grouped into three great categories according to the nature of the causal agents :—

(1) *Non-parasitic diseases.*—These result from some inherent quality in the plant, improper environmental condition of soil or climate, or from mechanical injuries. In this category are included such injuries as are caused by drought, water-logging of the soil, frost, hail, excessive heat or shade, deficient nutrition, lightning and other non-parasitic agencies. The injuries may be so insignificant as hardly to merit the name disease, but on the other hand they may materially affect the whole plant and even cause death. Diseases of this type are frequently more difficult to study than are those of parasitic origin, and very little is understood of many of them.

(2) *Virus diseases*—are due to an infective principle, or *virus*, which is transmitted from one plant to another, usually by specific insects. These diseases are highly infectious and constitute some of the most serious that affect plants. As yet, none has been found on tea.

(3) *Parasitic diseases.*—These result from the attacks of organisms, termed *parasites*. The attacked plants are usually referred to as "*hosts*", and as the word in this usage has not the socially accepted meaning, the term "*suscepts*" is sometimes used instead. Among the parasites are found representatives from the whole range of the animal and vegetable kingdoms. The animal parasites, or pests, belong mainly to the *mammals*, *arthropods*, which include the mites and insects, *molluscs*, represented by snails, and

vermes or worms, of which the eelworms or nematodes constitute an important group. The plant parasites, with which alone we shall be concerned, are mainly to be found amongst the *flowering plants*, *e.g.*, loranthus and mistletoe, *algae*, *fungi*, and *bacteria*.

There are no very strict divisions between these three classes of diseases. The virus diseases could well be included in the parasitic class on the grounds, as is sometimes considered, that they are caused by organisms too small to be seen even with the aid of a high-powered microscope. Even the division between parasitic and non-parasitic is not always clear. Amongst the parasitic diseases are usually included cases in which the invasion of the parasite is dependent upon a previous weakening of the plant by climatic or other environmental condition. In such cases the initial cause is non-parasitic, though the later entry of the parasite may increase the extent of the injury. Moreover the bringing together of a host and its parasite does not necessarily result in disease ; climatic or other environmental conditions must be favourable. It may thus be argued that the non-parasitic factor plays a part equal in importance to that of the parasitic agent in causing the disease.

It sometimes happens that a disease originally considered to be of parasitic origin is later shown to have a non-parasitic causation. The "bitten off" disease of tea seedlings and the "Diplodia" disease of tea bushes in Ceylon are two such examples. In other cases the reverse is true. But it is a safe rule to regard any disease of unknown origin as of parasitic causation, particularly if its occurrence in any way suggests that it is transmissible.

Among plant parasites the fungi stand pre-eminent, and, following the publication in 1853 of Anton de Bary's classical work on "Die Brand Pilze" which established their parasitism, the science of plant pathology has been built mainly on the study of their characteristics. For this reason, plant pathology and economic mycology (study of fungi) are almost synonymous terms.

Fungi are plants of relatively simple structure. In their simplest form, as in the yeasts, they may be merely rounded cells, but more typically they consist of delicate branched threads or *hyphae*, which individually are barely visible to the naked eye.

Collectively they form an interlaced tangle of cobwebby or woolly appearance, and this is termed the *mycelium*. A mycelium is, therefore, the vegetative body of a fungus, and its chief functions are the absorption of food and the nutrition of the reproductive system. As a general rule the mycelia of parasitic fungi are embedded within the tissues of the host plants, but their presence is made evident by lesions in the form of spots, cankers, rots or other symptoms of varied character. In some cases the hyphae are compacted to form cord-like strands termed *rhizomorphs*, which when running through the soil closely resemble roots; they afford a means by which the fungus can grow from one place to another. Such cords are not confined underground; they may occur on aerial parts, *e. g.*, "Horse hair blight", the cords of which closely resemble horse hair.

Like other plants, fungi pass through two phases in their life cycle, the vegetative and reproductive. Fungi reproduce themselves vegetatively very readily. Fragments of the mycelium when detached and placed in new situations, will continue to grow if conditions are suitable, and for that reason care has to be taken of disposal of diseased material. Some fungi also produce special aggregates of mycelium termed *sclerotia*. These vary very considerably in size and shape; they are hard, usually dark coloured, and well stored with food. They can withstand adverse conditions which would prove fatal to ordinary mycelia, and their function is purely reproductive. All fungi, with few exceptions, however, have special reproductive bodies, termed *spores*, which are of microscopic size. They have various names such as conidiospores, ascospores, basidiospores, etc., depending upon their method of formation, but in function they are alike, serving the same purpose for fungi as seeds do for the flowering plants. Owing to their minute size they are readily dispersed by air currents, though insects, birds and other animals, not excluding man, assist in their dispersal. The dissemination of minute spores of parasitic fungi, owing to their adherence to clothing, agricultural implements, planting material and merchandise, constitutes a real danger. The probabilities of a spore finding a suitable medium in which to grow is very small, but that is compensated for by the prolific numbers produced.

Fungi differ from most other members of the vegetable world in that they do not possess chlorophyll, a green colouring matter essential for the production of the world's food supply. The absence of chlorophyll affords a ready means of distinguishing the fungi from other filamentous plants such as the algae; also, it supplies the reason for the great economic importance of fungi. Being unable to manufacture their essential nutritional requirements from simple inorganic materials, owing to the absence of chlorophyll, the fungi are dependent on extraneous sources of organic food. That food supply can only be obtained from animals or plants, alive or dead.

The natural habitat of fungi is the soil. Were it not for the food requirements of fungi and bacteria, an even simpler group of organisms also without chlorophyll, there would be a great accumulation of fallen leaves, stems, fruits and animal remains on the soil surface. This litter, however, contains organic substances which the fungi and bacteria cannot themselves elaborate but which can be used for their nourishment. The complex organic substances are split into simpler compounds, some of which ultimately become again available to the living plant. The degeneration or decay of organic litter resulting from the activities of fungi and bacteria is not unrelated with soil fertility, though the full importance of fungi is possibly not yet fully recognised. By initiating decay, fungi may, however, cause heavy losses when such commodities as stored food or timber become the centres of their activities.

Organisms which live solely on *dead* organic material are termed *saprophytes*; those able to obtain their nutriment at the expense of *living* animals or plants are *parasites*. The majority of fungi are saprophytes, fulfilling a function as scavengers, but a few are *obligate parasites*, unable to live on dead matter even of their own killing and so are dependent upon the continuance of life of the host for their own support. Between these extreme classes are many gradations. There are fungi which normally live a saprophytic existence but are able at times to invade a living plant when the latter is weakened by age, mechanical injury or other cause. Others

can successfully invade, even when their hosts are vigorous, and then live saprophytically on the killed tissues. Some can attack only specific hosts, of one order, genus or even species while others can parasitise almost any plant with which they come into contact.

The intimate association of a fungus with a green plant is not necessarily one of parasitism. The association may be *symbiotic* and to the mutual benefit of both organisms. A well-known example of symbiosis is to be seen amongst the leguminous plants wherein the bacteria of the root nodules obtain their carbohydrates from the plant, and in return supply the green plant with nitrogenous materials. A fungus in symbiotic association with an alga (a green plant of simple structure) commonly forms a lichen ; in association with plant roots, fungi form what are known as *mycorrhiza*. Mycorrhiza are essential for the healthy growth of many orchids, but little is known of their value to other plants, such as tea, with which they are commonly associated.

The essential difference between a saprophyte and a parasite is that the former cannot gain entry into a living host plant, or having gained entry it cannot subsist. The ability or otherwise of a plant to withstand attacks of parasitic organisms are termed *resistance* and *susceptibility*, respectively. The predisposing cause of these conditions constitutes a large, yet fundamental, problem for plant pathology. The characters on which resistance depends are usually obscure, but it is sometimes possible to indicate, in specific instances, an association of certain characters with an ability to resist invasion.

In any case of parasitism not only are there two organisms, the host and the parasite to be considered, but the environmental conditions also, by materially affecting both organisms, constitute an important factor. The effect of environment, particularly climate, on the incidence of certain diseases is very apparent in that some diseases are seasonal. In some cases it may be possible to foretell an outbreak of disease from the meteorological conditions, as definite conditions of moisture and temperature are necessary for the germination of fungus spores and the initiation of a parasitic attack. In general, environmental conditions determine whether a

susceptible plant will become parasitised or not ; they may also, if uncongenial to an otherwise resistant host, so lower its powers of resistance that it becomes susceptible to attack by fungi from which normally it is immune.

Good agricultural methods, by maintaining inherent resistance at a high level, and good plant sanitation, by removing sources of infection and preventing the formation of conditions favourable to infection, as far as is humanly possible, may do much to check disease. But it would be fallacious to conclude that the presence of disease is always indicative of bad agriculture. As is frequently found with root diseases, the very conditions which favour the host also favour the parasite. It is sometimes possible, with annual crops, to evade particular seasonal diseases by growing early maturing varieties, which, though susceptible, are harvested before conditions become suitable, and infecting spores become sufficiently abundant to cause serious harm. Suitable crop rotation is also an important factor in reducing the liability to disease. But neither of these methods are applicable to permanent crops like tea.

Cultivated plants as a rule are more susceptible to fungus diseases than are their wild prototypes. This may be a result of cultivation and a resulting development of more succulent structures, having thinner cell walls which offer less mechanical resistance to penetration by invading fungus hyphae, or, more probably, it is a consequence of interference with natural selection. In nature, the continued existence of a species depends upon its ability to reach maturity ; an inability to reproduce its kind results in extermination. If a species tends to increase, its diseases tend to increase correspondingly and so cause a diminution of productivity. Thus an equilibrium or natural balance is set up. Resistance to a specific disease, however, is a genetic character known in many cases to be inherited in accordance with Mendelian laws. In nature, the more susceptible individuals fail, and selection is directed towards resistance ; but cultivated species are selected mainly for other desirable characters. The possibility of the production of varieties which combine resistance to specific disease with other desirable characters is, however, a subject not overlooked by plant breeders.

When a host and parasite have long been associated, as is the case when both are native of the same country, there is a tendency, as already explained, for the host to build up a power of resistance and for a balance to become established. The introduction of another parasite from abroad may find the host unable to withstand it, and, given suitable conditions, an epidemic may result. Some of the worst epidemics amongst plants have been caused in this way. The chestnut tree blight in the United States followed the introduction of a fungus on a resistant species from China and the mildews of the grape vine and gooseberry reached Europe from America. Nearer home, the first occurrence of oidium on rubber in Ceylon coincided in time with the importation of budwood from the Dutch East Indies for grafting purposes, and it is a matter for speculation whether the disastrous coffee leaf disease was not an importation from Africa. The introduction of parasitic fungi on seeds or other planting material is, therefore, a very real danger, and the need for efficient quarantine and inspection of such imports cannot be overrated.

It is, of course, not essential for a new parasite to be imported before an epidemic may occur. Sporadic disease, *i.e.*, those which affect a plant here and there, given favourable conditions which either lower the resistance of the host or increase the vigour of the parasite, may become epidemic. Neglect of certain diseases, thereby allowing the production of infective spores to proceed unchecked, may have serious consequences, particularly where extensive areas are planted with one perennial crop susceptible to the disease, as the risk of a spore meeting a suitable host is much enhanced.

In the foregoing is briefly sketched the economic importance of fungi in the *role* of parasites as a causative factor of plant disease. They may, however, cause disease in animals also, particularly insects, and then their activities may be beneficial to the agriculturist if the parasitised insects are plant pests. The use of fungi for the biological control of insect pests, however, has not met with much success.

A FURTHER TRIAL WITH TRICHOGRAMMA.

C. B. REDMAN KING.

In a previous article* an experiment was described in which xxii
the egg parasite, *Trichogramma evanescens*, was tested in the field for its efficiency against the Tea Tortrix, *Homona coffearea*. This experiment was repeated early in 1935, the plan and technique being the same as before, except that a unit of 5,000 parasites instead of 1,000 was used. The treatments may be recapitulated as follows, each treatment being duplicated :—

(1) 5,000 parasites released at centre bush of plot.

(2) As for (1), but 10,000 released.

(3) As for (1), but 20,000 released.

(4) 5,000 parasites released on each of two bushes.

(5) 5,000 parasites released on centre bush every other day until 20,000 had been liberated.

Parasitised eggs were put out on December 28th, 1934, in the same way as before which proved quite satisfactory, *i.e.*, the eggs were stuck on small manilla labels by means of rubber solution, and the labels were attached to an iron rod passing through the appropriate bush. Emergence was observed to take place two days later.

The tortrix eggmass population was decidedly greater in most of the plots than in the case of the previous experiment, and in all but one of the plots parasites managed to gain a foothold. Figure 1 is a diagram of one of the plots, showing the population of eggmasses at the first examination, figures 2 and 3 showing the same at subsequent examinations.

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* Tea Quarterly, Vol. VII, Part I, page 15 *et seq.*

Results in brief of plot 4a.

		Total Eggmasses.	No. of Eggmasses parasitised.
1st Examination,	January 3rd, 1935	205	0
2nd do	January 16th, 1935	313	53
3rd do	February 5th, 1935	10	3

The complete figures for the ten plots are set out in the following table :—

EXAMINATIONS

Plot	1st		2nd		3rd	
	Total Egg-masses	Parasitised Eggmasses	Total Egg-masses	Parasitised Eggmasses	Total Egg-masses	Parasitised Eggmasses
1-a	40	0	28	4	0	0
1-b	32	0	61	1	7	0
2-a	53	0	72	6	1	0
2-b	95	0	77	14	5	4
3-a	92	0	78	17	5	0
3-b	16	0	22	3	1	0
4-a	205	0	313	53	10	3
4-b	10	0	13	0	1	0
5-a	51	0	76	12	2	1
5-b	69	0	34	4	4	1

The decline in the eggmass population as shown in the third examination was so heavy that no further examinations were made.

The first examination was made too soon after the parasites emerged to record any induced parasitism, and was carried out to show roughly how many eggmasses were available at the time, and to find out whether any natural parasitism was present. 205 eggmasses were found in the plot shown diagramatically in figure 1,

or an average of about one eggmass per bush (there were 210 bushes in the plot), a certain number of which would be too old for successful parasitism. No parasites developed in any of the 210* eggmasses found.

Figure 2 shows that 313 unhatched eggmasses were found on this plot thirteen days later, of which 53 were found to be parasitised. 7 of these were parasitised to an extent of 90% or more, one of them completely so. It is estimated that there were over 2,700 parasites forming the first field generation, which was about one quarter of the number liberated.

Figure 3 represents the state of affairs on February 5th. Only ten unhatched eggmasses were found, and three were parasitised poorly, about 90 parasites in all representing the second field generation. The number of parasites had dwindled, in 37 days, to about one-hundredth of their grand parents.

DISTANCE FLOWN BY TRICHOGRAMMA.

At the second examination on January 16th, a certain number of parasites were found to have established themselves on the outer bushes of the plot. These eggmasses must have been parasitised on or before January 9th, as the time which was found to elapse between parasitism and the blackening of the egg (the sole criterion of parasitism in making counts) at this time was about seven days. As the parasites began to emerge on December 30th, they had a maximum period of 10 days in which to reach the outer plants. Measurements showed that eighteen eggmasses had been parasitised at a distance of eight yards or more from their starting point in this time. As no bushes outside the plots were examined for parasites, it is possible that a greater distance may have been flown than the maximum 12½ yards recorded. During this period the weather was fine, with occasionally slight airs from the N. E. The dispersion of the parasites round the compass, with regard to their starting point was fairly even, as shown below :—

Direction from starting point	Number of parasitised eggmasses
N.	20
N.E.	11
E.	14
S.E.	13
S.	13
S.W.	13
W.	16
N.W.	12

*The parasite, I. *evanescens*, introduced from Europe, can easily be distinguished from the indigenous species, I. *erosicorins*, since the first-named is very dark, while the latter is a pale form.

					2	2	4		1	2			3		
			2		1				2		2		2	1	
	3				1								4	1	
	3			1		2	1	3				4	7	1	
	1		2	2	3	1			2	1	2			1	
	1	1	3	2	2		1	3			2				
	2	1	1	1	3	2		1	2		2				
			1	1						1			1	1	
	4	1	6									2			
4		3						1	1				1		
	1	1	1	2	1	1					1	2			
2		3		1						4	2		2	1	
3	3	5	1	2					1	8	1	1	1	3	
	1		2	1			2	1	1		3	1			
4		1								1					

Fig. 1.

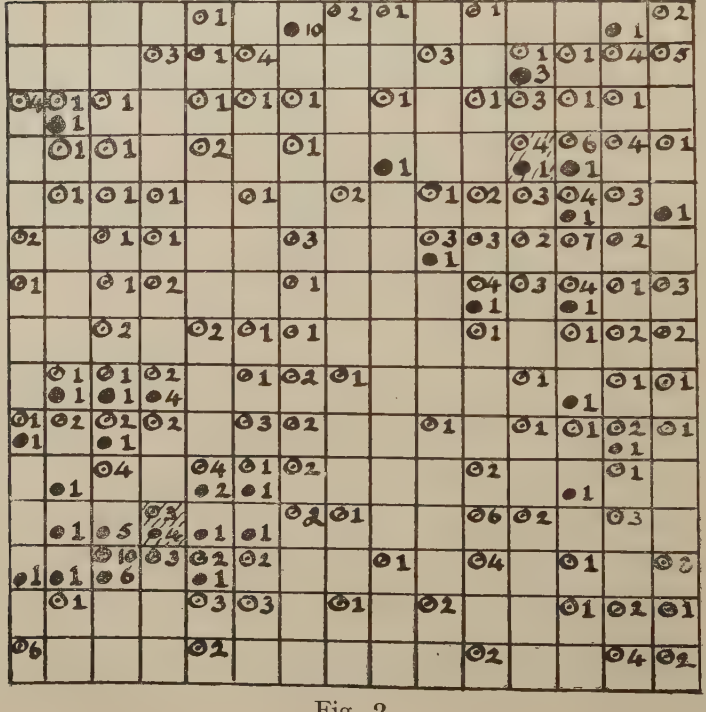

Fig. 2.

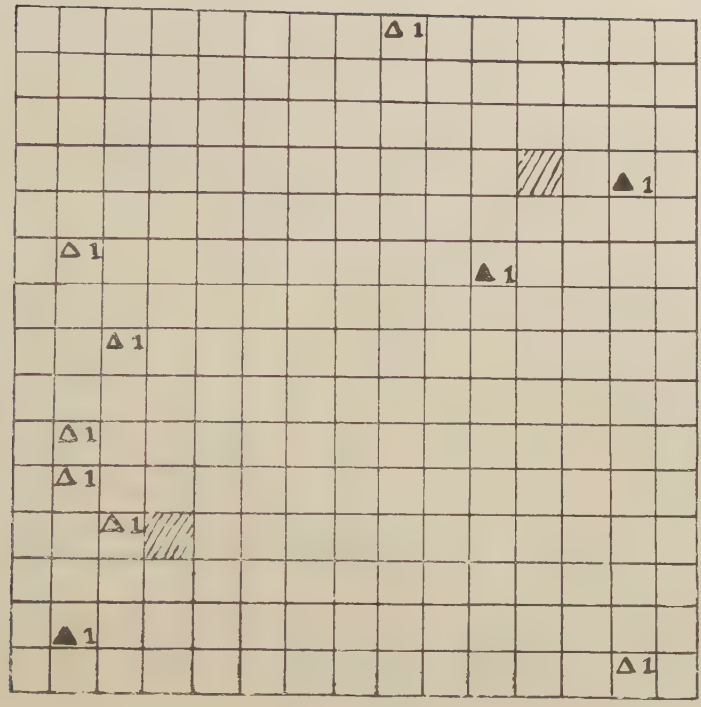

Fig. 3.

Each square represents a bush in a block fifteen bushes square. The shaded areas are those bushes on which 5,000 parasites were released.

Fig. 1.—Numbers refer to eggmasses found at the time of release of the parasites. Total population at this time was 205 eggmasses.

Fig. 2.—Figures indicate number of eggmasses per bush at date of the second examination; ⊙ represents unparasitised eggmasses, and ● parasitised eggmasses. A total of 313 eggmasses was found, of which 51, or 16·3 % were parasitised.

Fig. 3.—Numbers as before, the empty triangles representing unparasitised eggmasses, and solid triangles parasitised eggmasses. The total number found was 10, of which 3, or 30 % were parasitised.

The experiment again shows that the parasite entirely fails to achieve anything like control. The fundamental reason for this is undoubtedly the fact that the life periods of host and parasite are completely out of step with one another, in addition to the fact that there is practically no overlapping of Tortrix generations, which makes it impossible for the parasite to bridge the gap ; and there are no alternative hosts available to it, except perhaps in numbers as rare as, or scarcer than, Tortrix eggs themselves.

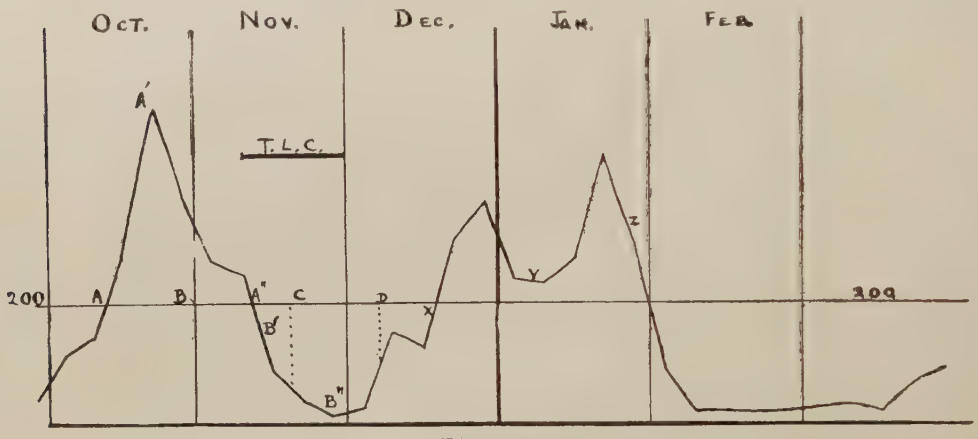

Fig. 4.

T. L. C.=*Trichogramma* Life Cycle.

The life cycle of Tortrix is 9-11 weeks in the field, while that of the parasite is about 16-19 days under similar conditions. The diagram (Fig. 4) shows the variation in the number of eggmasses in a certain area between October, 1932, and April, 1933. A line is drawn through the graph corresponding with a density of 200 eggmasses per acre. We select this figure arbitrarily as being a minimum for the parasite to gain a foothold. Suppose the parasites are put out at A, October 13th, and start parasitising right away, the first parasite of the next generation will come out on November 1, at B, where the number of eggmasses is greater than at the beginning, so that there is a good chance of a further generation. However, the second field generation will only begin at C, about November 19th, when the number of hosts has dropped considerably, and is still falling. Here one must take into consideration the very

small size of the parasite, and its relatively feeble flight. When eggmasses are scarce it has the utmost difficulty in finding hosts and so of propagating itself. The result is that the third generation will be very small indeed, beginning not earlier than December 7th (D), when host supplies are still low. The next Tortrix generation lasts about six weeks, and is totally insufficient for the parasite to reach overwhelming numbers.

Suppose now that the parasite is put out at some later date than October 13th, say the peak period of the Tortrix oviposition, in this case October 25th, A′. It may gain a better foothold than before owing to greater host numbers, but the first field generation begins to come out on the 13th of November, B′, when the host numbers are rapidly dropping. The result will be much the same as before.

Let us now assume a liberation on November 10th, A″, when the host numbers are the same as in the first case, but going down instead of going up. The first field generation begins to appear about the 29th, B″, when numbers are again very low, and again owing to the great difficulty of such a small parasite finding a host in the circumstances, the next Tortrix generation begins with an insignificant parasite population to combat it.

We may, therefore, abandon our attempts to deal with the Tortrix in the October generation, and start direct on the next one, which is the largest one of the year; and in our experiments with *Trichogramma*, this is what has been done. Referring again to the graph, if a liberation is made on December 19th, X, the first field generation will begin to come out about January 7th, Y, and the next one not earlier than the 26th, Z. At this period the host population is on the decline, but if everything goes well there might be a large percentage parasitised; yet there would be no control, since the great majority of this Tortrix generation will have escaped.

There are well-marked periods throughout the year when very few eggmasses are laid, and these periods cannot be spanned by the life-cycle of *Trichogramma* because it is too short. No egg

parasite is, therefore, likely to be of value unless its cycle occupies about two months and corresponds roughly with that of the Tortrix. In such a case, the parasite could be liberated at a time most favourable to itself for finding hosts, namely at the peak of the October generation, about the 25th, in the instance chosen, and its subsequent offspring would again find plenty of hosts in the second Tortrix generation

Although the above argument has been based only on the three seasons 1932/33, 1933/34 and 1934/35, there is reason to believe that Tortrix generations occur at about the same times every year, and that such generations are well defined with hardly any overlapping.

THE USE OF STEAM IN TEA FACTORIES.*

W. F. A. RIDLER, A. M. I. Mech. E.

It has long been known that where a supply of steam is required for process work in any industry, it is most economically obtained by the use of back-pressure or steam extraction engines, and, although it was usual in the early days of the tea industry to use steam engines and boilers for providing the necessary power, it was not until very recently that any use has been made of the exhaust steam.

Through the energy and initiative of a Dutch consulting engineer in Java, several factories have now been built in both Java and Sumatra in which the motive power is supplied by a steam engine and boiler, and the exhaust steam (supplemented if necessary) is used for heating the air required for the tea dryers and withering lofts.

* The Institute does not necessarily endorse the views expressed in papers contributed by persons not members of the Staff.

It is found in practice that the amount of fuel burned in the stoves of the dryers, if burned in an efficient modern type of boiler, will provide sufficient steam for heating the air for the dryers, and this steam passed through an engine will provide the necessary amount of power for driving the factory, so that while drying is going on, the power is provided for no more than the cost of drying alone. It is, however, necessary to run the engine for some three hours for rolling only, before drying commences, so that the total daily operating cost exceeds the cost of drying only by the cost of the fuel that has to be burned to provide the power needed before drying starts.

Figures for a large factory in Java, which prior to conversion to the "all-steam" system, purchased electric power for driving the factory and used wood for drying and withering, show that before conversion the cost of power was 1·3 guilder-cents per half kilo of made tea, and the cost of drying and withering 0·4 guilder-cents per half kilo, making a total cost of 1·7 guilder-cents per half kilo of made tea. After conversion to the "all-steam" system, the total cost for power, drying and withering is 0·465 cents. In other words, the wood consumption has increased from 0·4 to 0·465 and the power is provided for only 16% more than the previous cost of drying and withering alone.

These figures are based on six months' working, and on a crop of approximately the same size as before the conversion.

For normal conditions in North-East India, South India and Ceylon, it is probably correct to estimate that the cost of the "all-steam" system will be about 25% more than the cost of drying and withering alone.

There is a further saving in that stove and chimney renewals are eliminated from the annual maintenance charges as far as the dryers are concerned, and it is well established that over a period of years the cost of repairs, depreciation and replacements is much less with steam plant than with internal combustion engines. The simplicity and reliability of steam plant in the hands of native labour is also a very attractive feature.

The ease and convenience of steam drying has to be seen to be appreciated. The temperature remains steady and can readily be controlled automatically. As an example of what could be done the writer saw the fermented leaf placed on the feeder of a "stone-cold" dryer, the steam being turned on at the radiators simultaneously. By the time the leaf had gone up the feeder and along the top row of trays the temperature was up to normal.

In the case of new installations, the dryers would be provided without stoves and the steam radiators are then fitted on the suction side of the dryer fan, but in the case of a conversion where stoves already exist there is no need to dismantle them. In the case of an "Empire" or "Paragon" dryer, the radiators would be placed on the side of the air chamber, and when in use the tubes would be plugged. If it is desired to use the stove, the radiator is fitted with a blank cover, the tubes are unplugged, and the stove operated in the normal manner. In the case of the E.C.P. dryer, the duct connecting the suction side of the fan can be removed and connection made with a special duct between the radiator and fan, and, if it is desired to use the stove, it is only necessary to disconnect the new duct and replace the old one.

The cost of a dryer with steam radiator and without stove is considerably less than a dryer with stove, and in the case of a new factory the total cost of steam plant and steam-heated dryers is only very slightly in excess of the cost of internal combustion engines and ordinary fuel-fired dryers.

In cases where steam plant is already in existence, it will probably be quite feasible to incorporate it in an "all-steam" system.

There are two main types of installation. In one, low-pressure steam only is used in the radiators, in which case a comparatively high back-pressure, about 25 lbs. sq. inch, is necessary in the exhaust main to heat the air up to the necessary temperature, and a comparatively large number of sections in the radiator. Alternatively, it is quite feasible to equip the radiator with one live steam section, in which case the back-pressure for the low-pressure sections needs to be only about 7-10 lbs. sq. inch.

Automatic controls are provided to discharge the exhaust steam to the atmosphere when the amount of steam is in excess of that required by the dryers and/or withering lofts, and alternatively to bye-pass the necessary amount of steam direct from the boilers into the low-pressure main, through a reducing valve under the control of a sensitive pressure governor, to keep the pressure in the low-pressure main up to the required figure when the demand for steam by the dryers exceeds the amount required by the engine, as, for example, at the end of the day when rolling has stopped and the engine is on light load driving the dryer fans only.

It should be clearly understood that if water power is available for working a factory, there is nothing to be gained by installing the "all-steam" system, and, similarly, it is not economical to use live steam alone for heating the dryers for the simple reason that the thermal efficiency of a direct-fired tea dryer stove, especially the modern types now on the market, is higher than the thermal efficiency of a boiler of the size under consideration. It is only in cases where water power is not available that the "all-steam" system offers such remarkable economy in working.

To take a typical example, consider a factory having 8 rollers and two 4-ft. dryers. The total power required will be in the neighbourhood of 80 b.h.p. The dryers will require, if woodfired, say 250 to 300 lbs. of wood per hour each. Now this 500 to 600 lbs. of wood, if burned in a boiler, will generate 2,400 lbs. of steam per hour, which, if passed through a modern high-efficiency steam engine, is more than sufficient to provide 80 b. h. p. As each dryer will require about 1,200 lbs. of steam per hour, the amount of fuel required for the dryers alone is sufficient, if burned in an efficient boiler, to provide the amount of steam required for both drying and power.

At high elevations the economy becomes more pronounced as the amount of steam required for the dryers decreases directly as the reduction in density of the air, and at 3,000 feet elevation the amount of steam required is only 88% of the amount needed at sea level, and at 5,000 feet 82% of that required at sea level.

The possibilities of the "all-steam" system merit close investigation when a new factory is under consideration and water power is not available.

It is, of course, immaterial what type of fuel is used and this would be the same as would be used for drying with direct-fired stoves.

REPORT ON COMPOSTING IN RELATION TO TEA CULTIVATION GIVEN BEFORE THE STANDING COMMITTEE OF AGRICULTURE OF THE PLANTERS' ASSOCIATION OF CEYLON ON SEPTEMBER 20TH, 1935.

T. EDEN, D. Sc.

Some months ago I was asked by the Chairman of your Standing Committee on Agriculture to write a minute on certain correspondence that had been received from Sir Albert Howard, the originator of the Indore compost process. The Tea Research Institute had for some time been paying very special attention to reports on the manufacture of compost under conditions of estate agriculture, and been at some pains to compare the recorded conditions with those in Ceylon. In that minute I used these words: "After very careful consideration, I am unable to recommend the process unreservedly until the practicability of the process has been tested under our conditions, but arrangements are now in hand for working a small unit capable of turning out 100 tons per annum." In the same memorandum I said "Under Ceylon conditions the only drawback to the process will be its cost, as far as we can see at present . . . . ." "Our estimate at present for the manufacture and transport for distribution of the finished product reaches the very high figure of Rs. 8·36 per ton . . . ." I gave my reasons for this apparently high figure and subsequently, at a meeting of the Central Board of Agriculture, I expressed the hope that experience would show how to reduce this figure.

I propose to-day to take up the story from this point, and to tell you what is the result so far of our enquiries into compost in this country, in relation to tea. Sir Albert Howard has made certain criticisms of our standpoint and, as is only right, we have had to weigh those criticisms very carefully and have gone a long way to meet them, as I hope to show you.

UNDERLYING PRINCIPLES

I think it is essential, before passing on to the practical side of composting, to discuss the underlying principles. It should be the aim of every serious-minded agriculturist to conserve the fertility of the soil. My own researches, along with those of other workers in the field of Agricultural Chemistry, have shown that the soil resources play a much more important part in the production of crop than the artificial manures that we constantly employ. To fritter away those resources is unsound policy, and especially is that true of soil organic matter. It is, therefore, important to return to the soil as much vegetable matter from a crop as possible. The saleable portion of a crop is usually only a portion of its growth; the residue, if harvested, should find its way back to the land so as to counteract the drain on its resources.

One of the striking properties about soil humus is that no matter from what varied sources it is derived, it has approximately the same proportions of carbon and nitrogen in it wherever it occurs. Roughly, it has ten times as much of the element carbon in it as it has nitrogen. On the size of this ratio quite a number of interesting soil properties depend, one of which is the availability of the nitrogen to the plant. If the ratio of 10 to 1 is greatly exceeded, nitrogen availability falls off. If it is reduced, the availability is enhanced, but often only at the risk of rapid loss by leaching. It is, therefore, essential that vegetable matter should be returned to the soil in a form which corresponds in carbon and nitrogen content to something like this ratio. Many crop residues do not fulfil this condition; they have much too high a ratio and their direct use will cause existing available supplies of nitrogen in the soil to be locked up temporarily (until nature has adjusted the equilibrium), with consequent risks

to crop production. In such cases what is needed is some process that will adjust the ratio before application. Composting admirably fills these conditions. The essential features of composting are that by adding nitrogen, and by microbial fermentation, which diminishes the carbon content, the carbon-nitrogen ratio is narrowed, and there results a valuable organic bulk manure with important and useful properties both chemical and physical. There are other types of compost besides "Indore" compost, and, in a general sense, the old-fashioned farmyard manure is a very near relation. It should be obvious that composting as a process is meant to facilitate outside the soil the same or similar adjustments as occur in the soil whenever vegetable matter is dug or ploughed in.

COMPOSTING AND GREEN MANURING

This survey enables us to consider in more detail two sets of questions:—

(1). When is composting superior to direct incorporation of vegetable matter in the soil ?

(2). How is it related to current practice in Ceylon ?

Taking the first question, I have already described the drawbacks of direct incorporation of residues high in carbon and low in nitrogen. These drawbacks have been well established by many experiments and experiences with such materials as cereal straws and sugar cane trash. Compost has adavantages when intensive cultivations of several crops per annum are carried out on the same soil. The crops are so short lived, before maturity is reached, that there is not time to wait for the soil and vegetable matter to come into the required equilibrium in the natural way. Especially for luxury crops in market gardens and green houses, where the period of uptake of nutrients is so short, it is essential that some pre-treatment should have taken place. The intrinsic value of these crops makes expenditure on this score economic.

These conditions are not met with in any extreme form, however, in tea cultivation. Our green manures, as usually used, have a narrow carbon-nitrogen ratio, and the leaf of tea prunings is just on

the 2 per cent nitrogen level which gives a suitable ratio. Moreover, the tea plant being a perennial, grown for a vegetative crop only, and expressly restricted to a vegetative type of growth, can absorb its nutrient throughout its life cycle, and the time factor is consequently greatly diminished in importance. We usually fork in our green manure loppings with some sort of artificial manure which includes nitrogen, and this nitrogen is capable of adjusting the carbon-nitrogen ratio if by chance we have over stepped the mark. In this connection it is of interest to note that recent work at the Rothamsted Experimental Station suggests that unrotted straw plus artificial manures applied direct to the soil is as useful as straw rotted with the same manurial additions prior to application. This is virtually a comparison between direct application with artificials on the one hand and compost on the other. Mr. E. H. Richards, who has been working on the chemistry of farmyard manure and composts for many years, informs me that his recent researches point in the same direction when time is not an important factor.

From these considerations it seems to me that a distinction must be drawn between compost largely or wholly made from an extraneous material on the tea estates, and compost made largely or wholly from green manures and tea prunings. The distinction is twofold, (a) there is a difference in agricultural value and (b) a difference in cost. I shall pass on to costs later and will confine myself now to the question of agricultural value. The position is that compost made from extraneous material involves a definite transfer of fertility from extraneous areas to tea land. Compost made from green manures and prunings which are grown on the same soil in which they are later incorporated does not supply added nutrient in anything like the same degree; whatever extra nutrient is provided comes from the added dung and the urine. The question as to whether apart from these latter additions composting green manures confers a direct benefit is, on the grounds stated above, somewhat problematical. In order to test this point we are laying down an experiment which will include green manures with and without added artificial dressings, and equivalent amounts of compost with and without the same artificial dressings.

COSTS

This brings me to my final observations on cost. Sir Albert Howard's view has all along been that our estimated costs were excessive, mainly because our out-turn of 100 tons was too small. As a matter of fact there is not an estate in Ceylon within my knowledge that has produced an amount as great as this except by having recourse to green manures and prunings.* To meet Sir Albert's objection we have extended our manufactory to a 400-500 ton unit, and to the end of July when water shortage put a temporary period to our activities. 172 tons had been turned out. But this has involved the composting of green manures and prunings to the extent of 2/3rds of our total output.

In contradistinction to trials in Ceylon, Sir Albert Howard has quoted costs in Travancore "where conditions are not unlike those in Ceylon". These costs in one case were as low as 68 Ceylon cents per ton for making the compost, and only Rs. 2·00 when distribution is included. This case he admits is not typical. The average cost he estimates to be Rs. 2·50. His further comments are: "These figures are a complete answer to the very high estimates put forward by the T. R. I. in Ceylon . . . . . it will be evident that I was quite right in taking strong exception to their (*i.e.*, the T.R.I.) figures."

I do not agree that the answer is anything approaching complete. Such figures mean absolutely nothing unless it is clearly stated how these costs are arrived at. I have recently both corresponded and discussed in person with the officer in charge of these Travancore experiments the method of costing employed. I quote from my informant: "No overheads are included in these figures, but even if they were we should not approach that given in *The Tea Quarterly*. Of course, our conditions here are perhaps unique in tea, since the Manager has control of all the estate cattle and the herd is housed at night in common sheds distributed over the estate. Again it is difficult to find useful work for all our men, and if they are not making compost they would possibly be put on to some non-essential job in order to find them work and wages. The total wages bill for the estate with or without composts is thus about the same, but in the former case we have done useful work." This obviously negatives

*Since this lecture was delivered an estate has been brought to our notice which has made 105 tons of compost from waste materials other than green manures and tea prunings.—T. E.

the comparison between Travancore and Ceylon conditions. Mr. Young, who has throughout worked and organised the trial in which we are interested, visited Travancore and brought back accounts of island estates surrounded by unlimited jungle waste and grass. Under these conditions composting is well worth while. A real transference of fertility is being made, and in allocating work, where the choice falls between making compost or scrubbing bushes for the same wages, I should have no hesitation in making the same choice.

A week or two ago I asked a number of estates who have made compost in varying amounts to give me some account of their costs. Some of these estates have not proceeded far enough to give any account at all, some have no accounts but I have a few figures to report to you. I include every reply to date. The last-mentioned is the estate where compost has been made with our technical assistance; the rest are independent ventures over which we have exercised no control, beyond disseminating copies of Sir Albert Howard's printed lectures and carrying out analyses of the finished product.

The first thing to notice is that the quantities manufactured are generally exceedingly small. That fact cannot be divorced from the conditions on tea estates in Ceylon that militate against large-scale manufacture, notably, lack of real waste material, lack of suitable sites for manufactories, and primitive or non-existent roads.

I have classified costs under four heads: (1) the collection of materials, (2) the transport of these to the pits, (3) the costs of manufacture at the pits and (4) the cost of putting out the finished material in the field (but not forking it in). These are costs per ton.

Estates A, B, and C costed everything, and their figures can accordingly be compared with the tentative estimate we previously gave. The average is Rs. 6·71 per ton which falls within our price class rather than Sir Albert Howard's. The highest of these figures comes from the estate that produced the greatest quantity. The cost of collecting materials is the serious item, and whilst larger quantities do not unduly influence costs of manufacture at the pits, the collection of material from a wider area has adversely affected the cost.

Estate D which used labour passing to and from work for the collection of all material shows a high figure for cost, but I am uncertain whether costs of digging pits, etc., is included. In none of the other cases has this cost been included as it is not a running cost.

Estate E used as much labour as possible passing to and from work and had unusual access to waste material (in part town refuse) at its door step.

Mr. Young's trial F is organised extremely well and the man power used is divided as follows per ton.

Manufacture at pits (including spare time collection of material)	$2\frac{1}{4}$ man days
Special collection of material	$\frac{1}{2}$,, ,,
Transport of material	1 ,, ,,
Total	$3\frac{3}{4}$,, ,,

These low costs could not be maintained if large quantities of gliricidia loppings, grevillea loppings and tea prunings were not available at no cost to the process. Fortunately too, the estate is excellently roaded, and rubber-tyred bullock cart transport saves much man power. As in the other two previous cases passing labour does as much transport as possible.

These costs show how composting has to be considered by each estate on its individual merit, and justify the opinion I expressed that we could not compete with Indian figures, which, on the first occasion I advised this Committee, were all that were available. It is abundantly clear that low costs can only be obtained by composting existing resources. If that is done, it is equivalent to trading in a valuable agricultural asset in order to reduce costs, and what is being paid for is a *transformation* of existing sources of fertility rather than an *increase* of fertility.

INDORE COMPOST ON CEYLON TEA ESTATES.

Estate	A	B	C	D	E	F	G	H
						T. R. I. co-operating		
% Green manure	56	100	15	No details	39	68	96	22
% Waste material	44	nil	85		61	32	4	78
Labour	Charged.	Charged.	Charged.	Uncharged	Part charged.	Part charged.	Charged.	Part charged.
Total quantity tons.	40·3	11·5	9·0	6·15	32·5	17·2	14·5	9·0
Costs Rs.								
Materials	4·86	1·80	·92	—	—	·25	—	·58
Transport		1·41	·49	—	1·53	·50	1·86	—
Manufacture	1·97	1·25	1·66	5·90	1·81	1·13	2·62	1·06
	6·83	4·46	3·07	5·90	3·34	1·88	4 48	1·64
Distribution	2·08	·73	2·95	3·30	1·14			
Total	Rs. 8·91	Rs. 5·19	Rs. 6·02	Rs. 9·20	Rs 4·48			

There are occasions when this transformation of existing supplies may rightly receive every attention. The cultivation of tea is so complex that it is not always possible to arrange matters exactly as one would wish. There are times when one would like both to have one's cake and eat it. It is not always possible to fork in prunings or green manures on account of climatic difficulties, and the custom is to leave these as mulch. Mulch, unless permanent, is only a second-best effort, and both in substance and in nutrient content is wasteful. Under these circumstances composting has a definite contribution to make. These materials can be composted for use at a convenient season.

My considered opinion still is that composting has not the general application to Ceylon tea culture that is possible elsewhere, and that the reason is partly geographical and partly inherent in current practices. I have no axe to grind but I have to express an opinion on agricultural matters which shall be general in its application. I have detailed to you the reasons why I have said that "I cannot recommend the process unreservedly" but I shall always be ready to examine local conditions and to advise when circumstances exist that are likely to make compost manufacture agriculturally advantageous and economically sound.

Note.—Estates G and H have replied to the questionnaire since the meeting at which this report was given. They are included for the sake of completeness.

DISCUSSION.

Mr. E. W. Keith asked for information about the quality of compost made on tea estates, particularly as to whether it compared favourably with that made at Indore.

Dr. Eden replied that the samples he had examined were in most cases quite up to standard. They were rather higher in nitrogen, but this was to be expected since green manure loppings were being used to an appreciable extent, and the original nitrogen content of these was higher than that of the residues usually gathered from annual crops or matured plants. It was common to find nitrogen content in Ceylon composts fluctuating between 1·0 and 1·5 per cent. Howard in his publications tabulated a "soluble humus" figure. Dr. Eden had no particulars as to how this figure was arrived at, so that a strict comparison between his figure and the Indore figure was not possible on that point. Using soluble humus in the sense of easily oxidisable humus, as determined by oxidation with 3 per cent. hydrogen peroxide, Ceylon figures were much higher than those at Indore. That too was not unexpected because of the less pronounced lignification of much of the material used in Ceylon.

Mr. C. W. Wightwick asked whether material should be put into the pits green or dry.

Dr. Eden stated that Sir Albert Howard definitely made a point of insisting that materials should be withered before use. He did not as far as he could recollect, give reasons for this, but it was not difficult to predict the advantage. It was better for the cattle and a withered material was more absorbent of urine. It did not pack so tightly in the heap when first made. There were difficulties under Ceylon weather conditions. Compost had been made satisfactorily from fresh materials but it was better to stick to the Indore recommendations wherever possible. Dr. Eden did not think that where this was impossible composting need be abandoned.

Mr. A. R. T. Gibbon said that he appreciated the benefit of carting compost on to fields poor in tilth and in green stuff, but on fields adequately provided with green manures and in good tilth did he understand Dr. Eden to say that forking-in of green manures direct was as good as composting.

Dr. Eden replied that he had said the benefit was problematical. This was the test case in Ceylon for the use of compost. Where new material was brought in the problem did not exist, but where the total quantity of green stuff added was to be the same whether composted or not, for the reasons stated there was reason to believe that the benefits of composting were minimised. The question was whether any alleged benefit more than compensated for the expenditure involved. He had ventured an opinion based on general agricultural chemical principles and supported by direct experimental evidence of an analogous nature. The experiment with tea was designed to clinch the matter.

Mr. Gibbon further remarked that climatic conditions on his estate did not lend themselves to the application of artificial manures at the time of forking-in green manures and prunings. How long after might their use be justified from the point of view of helping to adjust conditions of decomposition ?

Dr. Eden replied that knowing Mr. Gibbon's conditions a period of not more than 2-3 months was advisable.

Mr. C. E. A. Dias asked what proportions of vegetable matter and cattle manure were advisable.

Dr. Eden explained that in India it was advisable for domestic reasons not to use cattle dung in excess, and that Sir Albert Howard had made a point of showing that excess of cattle bulk manure conferred no benefits on the finished product. In the Ceylon experiments an admixture of 5 per cent. of cattle manure had proved satisfactory.

Mr. Dias asked whether compost would encourage earth worms.

Dr. Eden replied that the presence of organic matter reacted favourably on earth worm activities, other things being equal. One difficulty was that tea soils were acid, and had to be kept acid, because tea would not grow on non-acid soils. He thought, therefore, that since earth worms did not relish acidity, that was the main factor in limiting their activity and not lack of organic matter.

Mr. W. L. S. Gwatkin asked if excessive quantities of green manure were bad for quality in tea, and how did compost stand in this respect.

Dr. Eden replied that there were two aspects, the effect of green manure shade whilst growing, and the effect of incorporating loppings in the soil. On neither point had he any direct evidence though it was usual to suppose that excessive shade produced harmful effects. Sir Albert Howard had spoken in one of his pamphlets of the increased crop of better quality tea that would almost certainly result from the application of compost. Perhaps the wish was father to the thought. The South Indian work on this subject had not been confirmed when tried elsewhere.

Mr. J. D. Hoare drew attention to the large amounts of nitrogen applied in compost On the basis of a 5-ton application he worked out that the amount would be about 168 lb. of nitrogen per acre, or, for a 10-ton application such as is, apparently at times, used in Kenya, 336 lb. per acre. He asked why such large quantities were indicated and suggested that costs could be reduced by lessening the amounts to be applied.

He further raised the question of comparative costs of nitrogen per pound applied as between compost and sulphate of ammonia. He suggested that, taking the cost of compost at Rs. 6·83, the highest figure given in the costs supplied to the meeting, and sulphate of ammonia on a basis of cost delivered in the field, that costs would be 20·3 cents per pound for nitrogen in composts on a basis of 1½ per cent. nitrogen content, and 32·5 cents for the nitrogen in sulphate of ammonia per pound.

Dr. Eden in replying pointed out that the determination of the nitrogen content of composts was made on the dry weight of the composted matter which would be about 50 per cent. of actual weight. This being so the apparent quantities of nitrogen application given by Mr. Hoare would have to be halved as he had taken the actual weight in working out his figures. This would bring down the amounts of nitrogen applied in a 5-ton application to about 84 lb. per acre and for a 10-ton application to about 168 lb.

Similarly this would have the effect of doubling the cost per pound which would, therefore, be just over 40 cents when taking the highest cost brought out in the tabulation supplied to the meeting, but which would be proportionately lower for the other estate costs.

He further said that some of the nitrogen in compost was readily made available, but not all. There was, so to speak, a deposit and a current account. What the proportions were he could not say, but since the carbon-nitrogen ratio of compost was so well adjusted to that of the soil it was reasonable to suppose that the current account was small over a limited period. That was excellent from the point of view of steady availability, but it meant that total quantities as revealed by analysis were very illusory.

He was, however, in a very real difficulty about this question, but the proposed experiment would give some information on this point. There were other benefits due to compost in the shape of its effect on the physical nature of the soil so that equivalence or otherwise of nitrogen costs did not cover the ground. He was a little puzzled as to what were Sir Albert's views about the nutritional aspect. In a letter to Dr. Eden Sir Albert had suggested that the saving in artificial manures should be deducted from prime costs of compost manufacture, but in other correspondence Sir Albert Howard had stated that chemical composition was a minor matter, and that compost should be supplemented by artificials. Dr. Eden himself had suggested previously that compost might be used after pruning when the application was easy, and that later, when the bushes provided so complete a cover that a bulky manure was a difficult problem, artificials should be used till the next pruning cycle started.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 11-7-1935.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held in the Ceylon Chamber of Commerce Rooms, Colombo, on Thursday, the 11th July, 1935, at 10-30 a.m.

Present.—Mr. James Forbes (Jnr.), (Chairman), the Hon'ble the Financial Secretary, Major J. W. Oldfield, C.M.G., O.B.E., M.C., Messrs. F. A. Bond, I. L. Cameron, E. L. Fraser, R. P. Gaddum, J. D. Hoare, D. H. Kotalawala, M.S.C., A. H. Reid, S. C. Bisset (Secretary), and by invitation, Dr. Roland V. Norris (Director, Tea Research Institute) and Mr. A. K. Halliley (Acting Secretary, P. A.).

Absent.—The Director of Agriculture and Col. T. G. Jayewardene, V.D., M.S.C.

1. Notice calling the Meeting was read.

2. The Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon, held on the 15th March, 1935, were confirmed.

Major Oldfield asked the Chairman if the printed Minutes could not be printed with a larger margin to allow for filing purposes.

The Secretary was instructed to attend to this in future.

3. BOARD OF THE T.R.I.

(a) *Members of the Board.*—The Chairman welcomed Mr. F. A. Bond, nominated by the Ceylon Estates Proprietary Association to act for Mr. D. T. Richards, and Mr. A. H. Reid nominated by the Planters' Association of Ceylon to act for Mr. R. G. Coombe.

(b) *Experimental Sub-Committee.*—Messrs. F. A. Bond and A. H. Reid were appointed to act for Messrs. D. T. Richards and R. G. Coombe respectively.

(c) *Acting Chairman.*—A vote of thanks was recorded to Mr. R. G. Coombe for having served as Acting Chairman during the absence of Mr. James Forbes (Jnr.) in Java, as from the 8th April to the 8th May, 1935.

4. FINANCE

Statement of Accounts as at 31st May, 1935, a copy of which had been sent to each member of the Board was adopted without comment.

5. VISIT TO JAVA

The Board recorded a vote of thanks to the Government of the Netherlands East Indies, The Thee Expert Bureau, the Ceylon Government, the Ceylon Tea Propaganda Board, and to the Institutes and gentlemen concerned for the assistance they had rendered the Chairman and the Director during their recent visit to Java.

6. SENIOR SCIENTIFIC STAFF

(a) *Director, T.R.I. — Dr. Roland V. Norris.*—Announced that the Director returned from Java and relieved Dr. C. H. Gadd, the Acting Director on the 10th May, 1935.

(b) *Dr. T. Eden.*—The Chairman said that as announced in Circular No. A. 8/35 dated the 12th June, sent to each member of the Board, Mr. T. Eden had been awarded the degree of Doctor of Science in the University of Manchester.

(c) *Dr. F. R. Tubbs,*—Announced that this officer had been awarded the degree of Ph.D. in the University of London.

The Director said that much of the work submitted by Dr. Eden and Dr. Tubbs was based on their researches at St. Coombs and it was gratifying to know that this work in addition to its proved practical utility had received the cachet of academic approval.

The Board wished its congratulations conveyed to the above two officers.

7. *Baddegama Small-Holdings Officer.*—Announced that Mr. E. F. Kannangara had been appointed Small-Holdings Officer as from the 1st March. After preliminary training at St. Coombs and Gampola he had taken up duties at Baddegama as from the 25th March, 1935.

8. JUNIOR STAFF PROVIDENT FUND

(a) *Appointment of Trustee vice Mr. R. G. Coombe.*—The Board confirmed the Chairman's action in having appointed Mr. A. H. Reid to act for Mr. R. G. Coombe as a Trustee of the Fund.

(b) *Minutes of the Meeting of the Trustees held on the 29th May, 1935.*—The Chairman said that copies of these Minutes had been sent to each member of the Board under cover of Circular No. A. 9/35, dated the 12th June, 1935.

There were no comments.

9. PASSARA SUB-STATION

The affixing of the Institute's seal to the contract documents for the Passara buildings on the 11th May, 1935, was confirmed.

The Chairman announced that the road was now finished and the work on the above buildings commenced on the 1st July, 1935.

With a vote of thanks to the Ceylon Chamber of Commerce for the use of their room and a vote of thanks to the Chair, the Meeting terminated at 12-15 p.m.

S. C. BISSET,
Secretary.

NOTICES.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

Publications. Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not to the Director's Office.*

ROLAND V. NORRIS,
Director.

EDITORIAL

PASSARA SUB-STATION

The Passara Sub-Station has now been placed on a more permanent basis by the recent construction on Gonakelle Estate of a small laboratory and a bungalow for Mr. Austin. A bungalow for the Field Assistant has also been obtained on lease in close proximity to the laboratory.

These changes will greatly improve the facilities for work. Originally the station was provided almost entirely for investigations on Nettle Grub. More recently, however, manurial experiments, to supplement those in progress at St. Coombs, were started, and it will now be feasible to go a stage further and take up work on Shot-hole Borer

The facilities now available have only been rendered possible by the cordial co-operation of the Nayabedde Estate Company, Limited; the Colombo Agents, Messrs. George Steuart & Company, and the Superintendent of Gonakelle Estate, to all of whom the grateful thanks of the Institute are due.

TEA MANUFACTURE

In the course of recent work with the small-scale rollers on St. Coombs, designed to correlate the performance of these machines with the commercial plant, much attention has been paid to the nature of the dhools obtained. By examination of the dhools it is possible to obtain valuable information as to the rate and manner in which the pluck is broken up and separated into its component parts during rolling, and permanent pictorial records can be obtained for comparison with others derived from similar experiments carried out under different conditions.

The importance of such information will be realised if it be remembered that different portions of the pluck ferment at very different rates, and the more efficiently these fractions can be separated during roll breaking, the more even will be the fermentation, and the better the resulting infusions should be.

The great disadvantage of machines such as the C.T.C. roller and the various types of chaff cutters which were on trial in many factories during the past two or three years, was the fact that the dhools obtained, though homogeneous in regard to *size*, were highly heterogeneous in regard to make up. It could not be expected that such material would ferment in a uniform manner.

The present trend of factory experiments is in the opposite direction, the aim being, by the use of multiple roll breakers and other devices, to separate the dhool into fractions as uniform in *composition* as possible.

This practice has another important advantage in that the amount of grading to be done with the fired tea is considerably reduced. There is less opportunity, therefore, for greying of the tea to occur.

We are glad to publish in the present issue the results of some experiments carried out by Mr. F. R. Francillon based on the above considerations. Using the St. Coombs method of dhool analysis, Mr. Francillon has worked out a logical system of roll breaking and fermenting of which full details are given in his paper.

At the same time he describes the method he employs to avoid unnecessary handling of the leaf and undue use of the factory floor — both points which deserve much greater consideration than they usually receive.

TEA SOILS

In a recent publication* Dr. Harold Mann has summarised our present knowledge in regard to the various types of soil on which tea is grown.

The conditions of formation of tea soils are discussed and their special characteristics, physical and chemical, described. A section follows on the relation of soil to the quality of tea which is of much interest, though some of the views expressed will hardly find universal acceptance. After a further chapter on the influence of soil on the health and vigour of the bush, a more detailed description is given of the characteristics of the soils in the various countries where tea is grown.

* Imperial Bureau of Soil Science, Technical Communication No. 32, *Tea Soils* by Harold Mann, published by the Imperial Bureau of Soil Science, Harpenden, England. Price 2/-.

Dr. Mann has had unique opportunities of examining many of these soils on the spot, and his views will be of interest to all those concerned in the cultivation of tea.

TEA TASTERS' TERMS

In *The Tea Quarterly*, 1934, Vol. VII, pp. 129-133, a glossary of the terms used by tea tasters in the Colombo market was published. With the co-operation of the Ceylon Association in London and through the courtesy of Messrs. R. G. Bradshaw and H. B. Yuille we are now able to give a similar glossary of the terms in common use in London. This, we have no doubt, will be of much interest to those selling in that market.

ROLAND V. NORRIS.

THE STORAGE AND PACKING OF TEA

J. LAMB

That the moisture content of made tea, quality, and keeping properties are very closely related is well known to the practical man.

Time and energy, as well as money, spent on improvements in the manufacture of tea are wasted if due care is not taken over the storage of the resultant product, both in the factory and in transit. This particular aspect of the tea industry has been generally neglected in the past and Ceylon cannot claim to be innocent in this respect.

In Java different markets often receive individual attention in matters such as final firing and moisture content at despatch. There are very sound reasons for such a procedure, as in different parts of the world tea is subjected to very different conditions of humidity and temperature. Tea with a high moisture content will deteriorate much more rapidly in a warm than in a cold climate, but the rate and degree of gain of moisture by made tea is directly dependent upon the humidity of the atmosphere with which it is in contact. It is this fundamental relation between moisture content of tea and atmospheric humidity that I wish to deal with in this article.

Tea conforms to well-known physical laws and it is hoped that the following data will be of assistance to those carrying out trials with various types of packing materials. A study of this article will reveal that a trial shipment of tea in a packing material under test may be invalidated by conditions which are quite independent of the material being tested.

Made tea falls among the class of materials known as hygroscopic substances. Hygroscopic materials have a marked tendency to absorb water, and the amount of water so taken up tends to establish an equilibrium with the water vapour of the atmosphere.

The following table shows the behaviour of tea exposed to three different conditions of relative humidity.

Interval	Relative humidity		
	94%	80%	62%
	Moisture content of Tea (Per cent)		
0 days ...	3·0	3·0	3·0
4 ,, ...	5·6	4·7	3·2
9 ,, ...	11·8	6·5	3·4
12 ,, ...	15·0	6·9	4·1
18 ,, ...	16·3*	8·1	4·4
24 ,, ...	16·7*	8·5	4·4
27 ,, ...	17·9*	8·7	4·6
32 ,, ...	20·0*	8·8	4·6
35 ,, ...	20·8*	8·8	4·6
41 ,, ...	21·5*	8·7	4·5

The asterisk denotes that the tea had become mouldy.

It is evident from this table that in a very humid atmosphere tea gains moisture rapidly, while in an atmosphere of 62 per cent humidity the rise in moisture content is slow and terminates at about 4·6 per cent moisture content. In a damp atmosphere the moisture content showed signs of becoming established at 20-21 per cent of moisture, but at this stage the tea was so mouldy that further determinations were valueless.

The teas from different estates do not show any marked differences in their affinity for moisture.

Estate	Exposure to atmosphere of 94% Relative humidity for 7 days.	
	Before	After
	Moisture content of tea.	
	%	%
1. Pekoe ...	5·3	11·6
do. ...	5·0	10·9
B.O.P. ...	5·3	10·9
do. ...	4·9	11·9
2. B.O.P. ...	4·9	11·6
3. B.O.P. ...	4·4	10·6
4. B.O.P. ...	4·6	10·8

Drying out does not affect the subsequent hygroscopic nature of tea to any marked extent.

The following are results obtained with teas from the same estate which were all exposed on the same occasion for the same period. One set of teas with a normal moisture content of 4·5 per cent was exposed for several days whilst the other set was dried out in a steam oven before exposure.

		4-5% Initial Moisture	0% initial Moisture (Oven dried)
		Final moisture content %	
Invoice 8 B.O.P.	...	15·0	14·3
9 do.	...	14·9	14·2
10 do.	...	15·1	15·6
13 do.	...	15·6	15·0

Different dhools from one manufacture do not exhibit any difference of practical importance in hygroscopic properties.

Dhool	Fermentation	Hygroscopic values	
		Set I	*Set II*
1.	4-55 hours	7·2	8·0
2.	4-35 do.	7·0	7·9
3.	4-05 do.	7·0	7·9
4.	3-55 do.	7·1	7·6
5.	5-20 do.	7·1	—
B.B.	5-45 do.	8·1	8·0

The grading of tea does not separate out any material of characteristic behaviour.

The conclusions to be drawn from the figures is that the tea, *whatever its origin or grade*, tends to establish an equilibrium with the humidity of the atmosphere to which it is exposed.

The next question which arises is, does tea, having reached equilibrium with a damp atmosphere, lose moisture when exposed to a dry atmosphere ? In order to answer this question the following experiment was carried out.

Two grades of known moisture content were first exposed in an atmosphere of 94 per cent relative humidity for 10 days. They were then exposed to an atmosphere of 80 per cent relative humidity for a further 5 days, followed by exposure to 65 per cent relative humidity for 15 days. The following table shows that these teas first gained and then lost moisture and *still* obeyed the law of equilibrium between moisture content and relative humidity of the surrounding atmosphere.

	B.P.	B.P.
Initial moisture content ...	3·2%	4·2%
Moisture content after exposure in atmosphere of 94% relative humidity for 10 days ...	11·5%	12·0%
Moisture content after being moved to an atmosphere of 80% relative humidity and exposed for 5 days	10·6%	10·8%
Moisture after moving once more, this time to 65% relative humidity and exposing 15 days ...	6·9%	7·1%

These periods and humidity conditions approximate to those which would be encountered by fully exposed tea shipped from a Ceylon estate to London. Thus 10 days in an atmosphere of 94 per cent relative humidity would correspond to Colombo, Indian Ocean and Red Sea conditions, while 5 days at 80 per cent relative humidity would correspond to conditions in the Mediterranean. After this the relative humidity of the atmosphere would be much lower, and 65 per cent would be representative of conditions in London.

Samples of such a shipment of tea would show normal moisture content in London, since 6-7 per cent is not unusual in samples of tea taken at the time of auction. Nevertheless a moisture content of 11-12 per cent in a warm climate would be sufficient to produce rapid deterioration, which means that the tea would have suffered

in quality between the estate and London. It is not my intention to suggest that these conditions and results are hard and fast, but it is my contention that moisture content tests taken on the estate and in London give no indication of the condition in which the tea may have been during some portion of its transit.

The logical conclusion to which we are therefore forced is that where tea is subjected to a humid climate for any considerable period, an airtight and moisture proof package is essential. Soldered or effectively sealed metal foil is not permeable to moisture and is therefore suitable, provided that it is not punctured by the sharp ends of leaves or torn during packing or transit.

During the past year several other materials have been suggested as being suitable for packing tea. Amongst these were various grades of cellophane and a rubber coated paper. Certain grades of cellophane are highly permeable to water. Ordinary rubber prepared directly from latex is also permeable to moisture, a property due to the non-rubber constituents of the latex.

In the following test packets of tea $3\frac{1}{3}''$ x $1\frac{1}{2}''$ x $1\frac{1}{2}''$ were exposed to an atmosphere of 90 per cent relative humidity.

Test 1 *Cellophane.*

Packets sealed with gum	
Initial moisture content of tea ...	3·5%
After 3 days	8·7%
After 7 days	15·5%

Test 2 *Cellophane, Grade No.* 200

Packets sealed with gum.	
Initial moisture content of tea ...	3·5%
After 3 days	4·0%
After 7 days	5·8%

Test 3. *Rubber coated paper.*

Packets sealed with rubber solution.	
Initial moisture content of tea ...	4·2%
After 19 days	9·5%
After 29 days	12·8%

Test 4. *Patent paper lining.*

Sealed with gum.

Initial moisture content of tea	...		2·4%
After 9 days ...	...	...	12·9%

Test 5. *Patent paper lining, thicker quality.*

Sealed with gum.

Initial moisture content	...	...	3·0%
After 9 days ...	...	...	12·0%

Test 9. *"Pliofilm" a patent transparent rubber product closely resembling Cellophane.*

Sealed with rubber solution.

Initial moisture content	...	...	4·5%
After 11 days ...	...	...	4·5%

Further tests with an improved quality double paper lining were carried out in half chests. The linings were sealed with gum, and the chest nailed down in the usual way.

The tea, a broken pekoe, was packed at 4·0 per cent moisture. Details of samples drawn follow.

Chest I.

Stored in a Colombo warehouse for one month. September-October.

Edges of chest	...	6·6% moisture.
Middle of chest	...	5·9% ,,

Chest II.

Stored in a Colombo warehouse for two months. September-November.

Edges of chest	...	8·4%
Middle of chest	...	7·4%

Chest III.

Stored in grading room of St. Coombs factory for three months — September-December.

Bulked sample	...	7·6%

SUMMARY

Cogent reasons are given why tea should be packed in a lining which is impermeable to water vapour, when the chests are liable to be stored in a humid atmosphere. Soldered or sealed metal foils which are mechanically strong enough to resist puncturing and tearing fulfil requirements, but results of preliminary tests with various other substitutes are given.

The most satisfactory of these materials is a patent rubber product resembling Cellophane.

THE CULTIVATION OF TEA*

T. EDEN, D.Sc.

When I accepted the invitation to address your Association I was told by your Chairman that the abnormal weather conditions of the last two seasons had brought into prominence the question of cultivation, using the term in its restricted sense of the mechanical working of the soil. I have accordingly chosen to speak this afternoon on that subject; but soil cultivation has so many implications relating to other aspects of tea culture that I shall offer no apology for commenting, as occasion arises, on other aspects which appear to me to be relevant to the main question.

If I were to ask you now to give me your views as to why cultivation is regarded by agriculturists as a fundamental necessity, you would most probably combine in answering to the effect that it ensures adequate soil aeration. Here we find ourselves right at the heart of our problem, for it has to be admitted that experiments have shown no very striking direct effects; but rather that aeration and water movement are closely linked.

I think I can help you to appreciate this basic difficulty if I place the emphasis rather differently. The first reason for cultivation is to maintain the soil in a porous condition. For healthy plant growth the air in the minute pores and channels of the soil has to be constantly

*Lecture given before the Nuwara Eliya District Planters' Association, October 22nd, 1935.

renewed. Now the most effective way to keep air renewed is to ensure that those pore spaces are not blocked by water; the vital necessity therefore is drainage. Moreover, rain-water itself contains appreciable quantities of air dissolved in it, and by free water movement this air is made to contribute to the soil atmosphere. Aeration therefore is an indirect effect of cultivation working through the factor of water movement. Provided this movement is free, there seems for the purposes of aeration to be no need for excessive commination of the soil particles. Our ideas are apt to be coloured by the parallel of conditions ruling in systems of temperate agriculture where the necessity of a seed-bed tilth for small seeds is paramount. Those conditions do not apply to the culture of a perennial bush such as tea. Nevertheless, some form of cultivation is necessary, for the maintenance of porosity is really important particularly on land such as ours, subject as it is to soil erosion. The more rain we can absorb and pass through the soil, and the less rain that is carried away as run-off, the sounder will be our agricultural practice. I will therefore recommend moderate cultivation with a view to breaking the hard cap of the soil as an important check on run-off and soil erosion, and will couple with it the breaking of the shallow pans that are frequently found in our up-country tea soils particularly.

The second reason for cultivation is to suppress weeds and help root development. As far as weeds are concerned the problem is not important under the prevailing system of clean weeding, but there seems to be a reliable concensus of opinion that tea is not very efficient in thrusting its roots through resistant soils.

Thirdly, cultivation is to be recommended as a means of ensuring that the application of manures is deep-seated. There are so many facets to this problem that I shall not deal with them now, but reserve them for a fuller discussion later. Porosity, root expansion and manurial applications thus provide reasonable justification for cultivation, but before expanding these points it may be as well to clear away some misconceptions.

Of late there has been much discussion in the rubber industry about a system of management described as the "Forestry" method of rearing that crop. Cultivation as we know it has no place in this

system, and the question that arises is whether anything of the sort is applicable to tea. Can we afford to forego cultivation without loss? The answer is, I feel, entirely negative. Forestry methods imply a very careful economy of soil resources, it is true, and the protection of the soil that is achieved in the process safeguards the porosity side of the question, but it is not suitable for a quick growing crop where leaf is the first consideration. If we are to remove the chemical laboratory of the tea plant in part, it is essential that its renewal should be adequately rapid, and anything approaching forestry methods will not achieve that.

There is another set of facts that touches us much more closely. Experiments in N. E. India have shown that severe cultivation retards the growth and cropping capacity of tea. Had I been speaking to you some two months later I could have given you some first-hand comments on these trials, for I set out on a tour of Assam in a week's time. But although I have not at present this advantage, I have had the opportunity of discussing at length with Mr. H. R. Cooper of the Tocklai Experimental Station this aspect of their work.

The Tocklai findings are that cultivation in excess of that required to suppress weeds does no good and may do harm. In this connection it is interesting that even on farm crops at home summer cultivation, *i.e.*, during the growth of the crop, produces the same effect according to recent experiments at the Rothamsted Experimental Station. How then are we to relate these findings to our own conditions ? In the first place we must understand that soil erosion and run-off do not trouble cultivators in Assam and England, and that they can afford to discount losses of soil or manure if cultivation is restricted. But also there is a difference in degree. Cultivation during the crop production months in Assam is described by the euphemistic title of "hoeing", but it actually involves the slicing away and turning over of weed sod with a long handled mammoty some six or seven times a year. It is not surprising that root damage sufficient to cause loss of crop is liable to occur if this process is overdone. In a similar fashion, as everyone knows, the use of a sharp-cutting hoe at home can play havoc with shallow-rooted crops. Compared with these drastic operations envelope-forking is a very mild expedient.

These experiments therefore warn us against over-cultivation but they do not discredit the milder and less frequent forms common in Ceylon which are employed for quite different and cogent reasons. I propose now therefore to consider in more detail the kind of cultivation prevalent in Ceylon and to describe both its advantages and disadvantages.

CULTIVATION IN RELATION TO DRY WEATHER

At the Tea Research Institute's Conference held earlier this year we had an interesting exchange of opinion regarding drought problems. I think that the question of cultivation in relation to drought is sufficiently important to deal with this point again, even to the extent of repeating some of the arguments I used there. There is nothing good to be said for cultivation in dry weather in the conditions we have to face on the generality of estates in Ceylon. The breaking up of the soil at this time does not provide the protection of a dust mulch, as ordinarily understood in systems of dry farming, because this system only applies to cases where the water-table is relatively near at hand, *i.e.*, within some 6-10 feet. These conditions are not found on land with contours such as ours. The net effect of cultivation in drought in Ceylon is to expose a greater area of soil to the drying action of wind and sun, and to do root damage at a time when it is most dangerous, *i.e.*, when root regeneration is bound to be poor. Difficult as it may be at times, every effort should be made to transfer as much of the cultivation programme as possible to other times of the year. This plan has also advantages in the sphere of artificial manuring because manuring at this time will frequently accentuate drought deficiency. The reason for this is that the moisture that is left in the soil under these circumstances becomes highly concentrated with manurial salts and these high concentrations withhold the few remaining dregs of moisture from the plant.

CULTIVATION IN RELATION TO GREEN MANURING

For similar reasons, the forking-in of prunings and green manures during drought is to be deprecated. The amount of moisture they supply to the soil is quite small; they dry rapidly themselves, and they open up the soil even more than a straightforward plain forking.

Farmers at home are quite familiar with the phrase "letting the drought into soil" by injudicious cultivation, and the parallel holds quite well under Ceylon conditions.

Unless therefore this vegetable matter is composted it is better left as a leaf mulch. By protecting the soil from direct sunlight this mulch will preserve moisture in the upper layers of the soil in a much more efficient manner than our poor attempts at a dust mulch. It is not a highly efficient method of using green manures, but it is more expedient to lose some of the nutrient value of leaf-fall than to risk drought dangers. Where the mulch so formed is supplemented by a really good layer of Grevillea droppings, it plays a very important part in soil protection. In addition, it is a very fine protection from erosion when the later rains arrive. I would go so far as to say that, if you have easily accessible supplies of manna grass, the proposal to lay down a manna grass mulch in dry areas is worth considering. We have tried it at St. Coombs though not with all the paraphernalia of experiment. Its moisture retaining qualities are plainly to be seen, and recent work on coffee in Uganda suggests that its employment is coupled with definite benefits to plant growth and crop. When eventually it is forked in, it should be dressed with an ordinary artificial manure mixture, or, at any rate, with a nitrogenous dressing, in order to ensure its proper decomposition in the soil.

CULTIVATION IN RELATION TO ARTIFICIAL MANURING

It is perhaps as an adjunct to good manuring that cultivation plays its most important part. I have hinted at the disadvantages of manuring in dry weather, and one way of preventing undue nutrient concentration at the surface of the soil is to distribute the manure as uniformly as possible through a reasonable depth of soil. From a symposium I have recently read on cultivation of crops in dry areas in many parts of the world, it appears that the general experience is that shallow manurial applications are fraught with danger in places subject to dry periods.

There are other arguments on this point that are equally cogent The fine feeding roots of tea are concentrated very largely in the cultivated and manured depths, so that, apart from any other considerations, a policy of shallow manuring tends to encourage unduly

root development in the soil depths that feel the effects of drought first. Moreover, phosphate and potash manures have not the mobility in the soil that nitrogen has, so that anything but deep forking localises the supplies of these nutrients.

Phosphates deserve a special word. In time, all forms of phosphatic manures revert in the soil to a type of compound that is only sparingly soluble. It is necessary therefore to distribute phosphates in those parts of the soil where the solvent action of soil moisture is reliably steady. Nothing could be more wasteful than the scratching in for a few inches of an insoluble manure like rock phosphate, (the saphos and safaga of commerce).

Lastly, in this connection shallow cultivation is not a good anti-soil erosion method, and with the loss of soil, loss of added manures goes hand in hand. These are to me convincing reasons for a reasonable policy of cultivation.

Now let us turn to the attendant disadvantages. In one form or another they culminate in root damage. I hope shortly to investigate this point in a joint experiment with the Tocklai Station and we shall try to make the results decisive. But provided the precautions regarding dry weather are borne in mind, I am not unduly perturbed by root disturbance from envelope forking. Roots like leaves, grow, work, become inefficient and die, and like leaves are stimulated to fresh growth by wound reactions. It is not very consistent to insist too much on root damage effects, when day by day a similar operation is going on, by means of plucking, in connection with the above ground portion of the bush. I have still to see in Ceylon an authentic instance of setback due to root damage. Some temporary check may possibly occur, but as in the case of tortrix attacks on leaves, the total effect over a period seems negligible.

I cannot see that alternate line forking every six months according to seasonal requirements constitutes a danger to root development, but rather, that for the reasons I have indicated, it is essential on estates which wish to maintain a reasonable standard of production.

A GLOSSARY OF TEA TASTERS' TERMS*

R. G. BRADSHAW AND H. B. YUILLE.

This list is confined as far as possible to terms in daily use on the London market and a good number are omitted, though sometimes used, which convey little or nothing to the planter.

Tasters should endeavour to give definite guidance to a planter who wants to trace a shortcoming in his tea to some incorrect factory procedure.

Some terms are difficult to define, such as "point" which cannot be tied down to any particular property, but is generally used to denote any characteristic, *strength*, *pungency*, *briskness*, which is sufficiently marked in a tea to carry that property into a blend.

The exact meaning of *briskness* is difficult to determine. Most tasters use it to denote a *live* liquor as opposed to a *flat* one, but it does not indicate pungency.

Many terms are used to denote the same property or slight variations of a property. Thus *washy*, *weak*, *thin*, describe various degrees of thinness representing something wanting and undesirable. *Light* and *sweet* may be used to describe good liquors, although not so good as those shewing *thickness* and *strength*.

The terms *full*, *round*, *smooth* and *mature* all indicate an absence of bitterness or rawness and suggest strength. Such teas usually cream down well. *Fulness* gradually gives place to *softness* and then *dulness*.

The terms in the glossary below, are collected under four headings dealing with the appearance of the tea, the infused leaf, the liquors, and general characteristics. Particular manufacturing conditions which may account for some of the faulty characteristics are denoted.

* Compiled by R. G. Bradshaw and H. B. Yuille at the request of the Ceylon Association in London.

1.—DRY LEAF.

Brownish	... Leaf which is brown in colour.
Blistered	... Leaf swollen and hollow inside. Results from too rapid firing.
Black	... Leaf which is black in colour.
Choppy, Choppped, Cut	... Leaf chopped in the breaker or cutter rather than broken in the roller.
Clean	... Leaf free from fibre and dust and broken leaf or Fannings.
Crepy	... Applied to tea with shell-like crimped leaf.
Even	... Leaf true to grade and consisting of pieces of roughly equal size.
Flaky	... Leaf not twisted, but in flakes.
Grey	... Leaf grey in colour. Results from too much rubbing in sorting and cutting.
Silver tip	... Grey or pale coloured tip (not golden). Leaf which has been over-withered or damaged during sorting may give grey tip.
Some Ends	... Not in general use. Applies to small tip.
Stalk	... Usually indicates red stalk. Results from coarse leaf and too hard rolling.
Tippy	... Containing a large percentage of "pale" or "golden" tip.
Uneven	... Tea composed of uneven pieces.
Well twisted	... Fully withered leaf gives well-twisted tea. Usually applied in describing whole leaf grades.

2.—INFUSED LEAF.

Bright	... Bright in colour, denoting a good tea. The liquors of such infusions are usually bright.
Coppery	... Bright, copper-coloured infusion.
Dull	... Dark brownish or dull green in colour denoting a poor tea. The liquors of such infusions are usually dull.
Green	... Greenish in colour, results from under-fermentation or insufficient rolling.
Open	... The infusion has lost its twist. If open and bright denotes good quality.

Mixed / Uneven ... The infusion contains red, green and dark colours. Results from uneven jât, uneven withering fermentation or rolling.

3.—THE LIQUOR.

Brisk ... Having a "live" characteristic.

Bright ... Bright in colour and clear, with some briskness.

Body ... (See *Thick.*)

Colour ... Denotes colour but not necessarily a good tea—the term must be considered in conjunction with other characteristics.

Dull ... Brownish liquors which are neither clear nor bright.

Flat ... Lacking in briskness and pungency: Generally used to denote a tea that has gone off.

Fruity ... May arise from over-fermentation or leaf lying wet whilst withering.

Full ... A strong, coloury tea with no bitterness or rough character.

Raw / Harsh / Rasping ... A liquor which is bitter.

Light ... Pale in colour but does not necessarily denote a poor tea. Good quality, pungent teas are frequently light. Not to be confused with "thin".

Malty. ... Suggests slight high firing but not overfired. Used for quality teas well and properly fired. High firing will not produce a malty tea unless this character is originally present in the leaf.

Mature ... No rawness or flatness—akin to full.

Pungent ... Having astringency without bitterness.

Round ... (See *Full.*)

Smooth ... (See *Full.*) Not so pronounced as "full" but not a bad term.

Strength ... A combination of thick liquors and pungency or briskness. A tea which creams down well.

Soft	...	Denotes a lack of "life", pungency and briskness, not as poor a term as "flat".
Sweet	...	A light liquor that is not altogether undesirable.
Thick	...	A concentrated, bright red liquor which creams down well.
Thin	...	Lacking strength, body and briskness.
Weak	...	Thin and lacking in pungency and body. Similar to thin.
Washy	...	(See *Thin.*)
Plain	...	Lacking in tea characteristics, and wanting in flavour.
Weathery	...	A soft undesirable character found in rains teas.
Sour	...	Definitely a sourish taste through defective manufacture.
Heated	...	A dull, soft, fruity character attributed to defective manufacture.

4.—GENERAL CHARACTERISTICS.

Aroma	...	Usually denotes the presence of flavour.
Bakey	...	Defective or faulty firing, sometimes slightly over-fired.
Coarse	...	A liquor which may have some thickness but is deficient in quality. Results from coarse leaf.
Cream	...	A cloudiness obtained as soon as a strong tea which quality cools.
Dry	...	Slight bakiness.
Out of condition	...	A mouldy or unsound tea.
Flavour	...	A tea showing a seasonal or district flavour.
Gone off	...	Tea that has lost its fresh character.
High fired	...	Fired more highly than is desirable but not burnt.
Malty	...	A well fired tea, a desirable characteristic. Is present only at quality seasons.
Nose	...	Indicating some aroma on the dry leaf. May be bad or good according to further description.
Point	...	Some marked desirable characteristic. Accentuated briskness.
Quality	...	Denotes the presence of desirable characteristics

Stewed	... Tea lacking in common tea flavour, results from under-firing, or from too thick spreading on the firing tray.
Sweaty	... May result from unclean factory conditions.
Tainted	... Usually refers to some flavour, quite foreign to tea, *e.g.*, fruit, kerosene, etc.

SULPHUR TAINTS.

J. LAMB.

During the treatment of rubber trees with clouds of sulphur in a very finely divided condition, there is often a risk of sulphur falling on to tea bushes in the vicinity. Sulphur dust is also employed in some cases as a preventative measure against mite infections of the tea bush. With the co-operation of the Rubber Research Scheme a series of experiments was carried out in order to determine whether sulphur dust falling on to tea bushes would cause taint to appear in the made tea; and if so, how long the taint remained. Previous experiments have been carried out on this subject, but the results were confused by the appearance of taints in the control leaf plucked and manufactured alongside the dusted leaf; probably due to the absence of experimental machinery, necessitating hand rolling and improvised firing.

There are at least two possible ways in which taints may be caused by sulphur. Firstly, the retention of free sulphur dust by the flush on which it has fallen and subsequent inclusion of sulphur with the leaf at the time of manufacture. Secondly, absorption of sulphur by permanent leaves and the passage of noxious sulphur derivatives to the flush. In order to test out these two hypotheses, dust was applied to the experimental areas both immediately before, and immediately after plucking. Thus, in the first case, sulphur dust could be carried away on the plucked leaf. In the second case, the whole of the plucking interval would be available for the absorption of sulphur by the permanent leaves, and for any effects due to this to appear in the crop.

In addition, two intermediate applications were tested. An experiment on these lines was carried out on Gonakelle Estate, Passara with the kind co-operation of Mr. G. Kent Deaker.

Four one-acre plots were used, and 10 lbs. per acre of sulphur applied at four different times. The plots were plucked at intervals of 9 days, and the leaf was conveyed to St. Coombs for manufacture.

The samples were submitted to five different Colombo buyers for report.

When these teas were sent for report, samples of ordinary St. Coombs B.O.P. were included in such a manner that the tasters dealt with sulphur dusted aud ordinary teas alternately. This arrangement safeguarded against taints being retained on the tasters' palates.

The details of the experiment follow in tabular form:—

Dusted	Plucked	Interval between dusting and plucking		Tasters' Report
		Plot A.		
Aug. 22	Aug. 22	(Dusted before	nil	Badly tainted
,, 31	,, 31	plucking)	nil	,, ,,
		Plot B.		
Aug. 19	Aug. 22		3 days	Slightly tainted
,, 28	,, 31		3 days	,, ,,
		Plot C.		
Aug. 17	Aug. 22		5 days	Slightly tainted
,, 25	,, 31		5 days	,, ,,
		Plot D.		
Aug. 22	Aug. 22	(Dusted after 1st		Free of taint
	,, 31	plucking)	9 days	Slightly tainted
,, 31	Sept. 9		9 days	,, ,,

Control (undusted) leaf was obtained from Plot D on August 22nd. On the occasion of the second plucking on August 31st control leaf was obtained from bushes adjacent to the experimental area. Both controls were reported as free of taint.

A strong smell of sulphur was observed during the firing of teas from Plot A; the liquors had a most objectionable taste, and smelt of sulphur while hot. These features were much less evident in the teas from the remaining plots, and this indicates that the application of sulphur in Plot C, where absorption could not have produced any effect, caused bad tainting, whereas that applied to other plots, where the time interval enabled absorption, if any, to occur, caused only a slight tainting. Since some of the tainting in the remaining plots must have been due to sulphur remaining on the shoots which were plucked subsequently, it appears that even if absorption by the older leaves occurs, it is of minor importance.

Analysis of the made teas indicated a rise of total sulphur content after dusting, as shown in the following table:—

Plot	Interval between dusting & plucking (days)	No. of applications of sulphur dust	Percentage of sulphur in dry matter
A	0	1	0·371
A	0	2	0·323
C	5	1	0·462
C	5	2	0·512
D	—	0	0·276
D	9	1	0·312
D	9	2	0·354

The weather conditions during this experiment were difficult. Dryness and high winds, culminating in absence of dew in the early mornings, at which time dust was applied, resulted in some of the sulphur failing to stick to the leaves. Later in the experiment rain fell, amounting to over an inch on the 29th.

Rainfall during rainy days on Gonakelle.
(August 1934.)

5th	9-30 a.m.	0·05''
12th	3-30 p.m.	0·02''
23rd	3-30 p.m.	0·07''
25th	9-30 a.m.	0·02''
25th	3-30 p.m.	0·13''
26th	3-30 p.m.	0·62''
27th	3-30 p.m.	0·01''
29th	3-30 p.m.	1·07''
30th	3-30 p.m.	0·09''
31st	9-30 a.m.	0·07''
31st	3-30 p.m.	0·03''

A further examination of the problem was carried out on St. Coombs. Four one-acre plots were employed. A and B received 5 lbs. dust per acre, and C & D 2 lbs. per acre. A & C were dusted immediately before plucking, and B & D immediately after plucking. The details of the various applications of sulphur dust are given below, together with the tasters' reports. The experimental procedure was the same as in the previous experiments.

(a). Dusting and plucking on 31-1-35.

Plot A — dusted with 5 lbs. and plucked
B — plucked and dusted with 5 lbs. } Badly tainted
C — dusted with 2 lbs. and plucked
D — plucked and dusted with 2 lbs.

(b). Second Dusting and Plucking on 9-2-35.

Plot A — dusted with 5 lbs. and plucked	Bad taint
B — plucked and dusted with 5 lbs.	Slight taint
C — dusted with 2 lbs. and plucked	Bad taint
D — plucked and dusted with 2 lbs.	Slight taint

(c). Plucking only on 4-3-35 (23 days after last plucking — see Section b).

Plot A plucked only
B ,, ,,
C ,, ,, } Free of taint
D ,, ,,

(d). Dusting on 13-3-35 and plucking on 26-3-35 (13 days after last plucking).

Plot B dusted with 5 lbs.
C dusted with 2 lbs. } Tainted

(e). Plucking only 16-4-35 (21 days after previous plucking, 34 days after previous dusting).

Plot B
C Free of taint

Total rainfall since previous plucking:—

Plucking	(a)	...	0·0"
,,	(b)	...	0·0"
,,	(c)	...	1·03" 6 wet days in 23.
,,	(d)	...	3·19" 10 wet days in 13.
,,	(e)	...	8·91"

These data suggest that the length of interval between dusting and plucking is more important than rainfall, since 3·19 inches of rain did not remove taint in an interval of 13 days, whereas taints disappeared after 23 days during which only 1·03 inches of rain fell.

The rainfall in these two cases was of the same type as the following analysis shows:—

(c)		(d)	
	0·11 on 14-2-35		0·01 on 16-3-35
	0·04		0·09
	0·12		0·33
	0·71		0·88
	0·03		0·55
	0·02 on 24-2-35		0·04
			0·27
Total	1·03		0·16
			0·60
			0·20 on 26-3-35
		Total	3·19

There are not any indications of an accumulative effect due to successive dustings. The probability is that, once sulphur dust, in a very finely divided condition, sticks to the leaves of a tea bush, anything akin to normal rainfall is not sufficient to wash it off.

CONCLUSION.

Sulphur dust in a finely divided condition applied to tea bushes in as small a quantity as 2 lbs. per acre may cause marked taints.

After such tainting has occurred it is necessary to allow an interval, after the application of the sulphur dust, sufficient for the growth of flush on which dust has not fallen.

NOTES ON GREEN LEAF SIFTING AND FERMENTATION*

F. R. FRANCILLON.

I was fortunate in enlisting Mr. Whitehead's interest and valued co-operation in the subject matter of these notes. We wish to make it clear that we do not claim to have made any remarkable discovery, but have arrived at certain logical conclusions, which are the outcome of a series of closely reasoned experiments carried out following the installation of a C.C.C. Multiple Green Leaf Sifter. Our object was to arrive at the best possible method of obtaining a bright and even fermentation of dhools.

The machine needs no description as it is well known. As supplied by the makers the top tray was fitted with No. 5 mesh throughout, while in the lower tray the upper half was fitted with No. 6, and the lower half with No. 8.

After charging two rollers with 432 lbs. of withered leaf and rolling for five times, the first day's shifting gave the following results.

Over	No. 5	95 lbs. or	22·09%
Through	,, 6	232 ,, ,,	53·96%
Through	,, 8	12 ,, ,,	2·79%
Over	,, 8	91 ,, ,,	21·16%

*The Institute does not necessarily endorse the views expressed in papers contributed by persons not members of the Staff.

The material falling through No. 6 was very uneven, and contained all the smaller, as well as a large percentage of the larger, particles of leaf and long ends. The material falling through No. 8 was more even, being composed chiefly of medium sized fragments with a number of long ends.

It was the heaped up uneven dhool below No. 6, and the mere sprinkling of dhool No. 8, that led to a series of experiments, a précis of which is given in these notes.

The first point to clear up was whether evenness, and brightness, could be achieved by the conditioning of the air over, and around, fermenting dhools, or whether the only way this could be obtained was by the separation of tender from mature leaf.

This led to experimental plucking in the field which was undertaken and closely supervised on two estates on the following lines: the tip and first leaf only were plucked and put into one basket, while the remaining second leaf and stalk were plucked and put into a second basket. A normal pluck as a control was also undertaken. In both instances the brightness and evenness of the resulting dhools and infusions were most remarkable as regards the tip and first leaf manufacture. The second leaf and stalk, as was to be expected, were not so bright, but again evenness was a definite characteristic. Infusions from the control pluck were mixed — containing bright young leaves and dull olive green older particles.

Having demonstrated to our satisfaction that the separation of tender from mature leaf is essential to bright and even infusions, it was next considered as to how this could best be effected.

The cost of plucking as described is prohibitive. It was found that in a field where the normal average would approximate 25 lbs., it was only possible for a good plucker to bring in a maximum of 4 lbs. of bud and first leaf. The problem, therefore, resolved itself into the improvement of roller battens, and methods of sorting in the green stage prior to fermentation.

No claim is made as regards roller battens though "Pictures" made it abundantly clear that some are preferable to others — though to what extent this can be attributed to wither, or type of leaf, it is hard to prove or disprove.

"Pictures" are taken as follows; the method being that developed by Mr. Lamb at St. Coombs: A fair sample of approximately 1 ounce of dhool is placed in a tea cup, or similar receptacle, which is filled with boiling water. The dhool, or leaf, is left until all twist has been removed, and it has attained a maximum degree of flaccidity. From this a small fair sample is taken, thoroughly dried on blotting paper, and every particle of leaf carefully unrolled and spread out on white paper. It is essential that *all* particles, however small, are included in order that a true picture of what has taken place can be made. The evenness, or unevenness, becomes apparent immediately, and such pictures can be preserved for comparison by covering them with a piece of glass.

A definite claim is made, however, that by the careful grading of dhools a distinct improvement can be effected.

We must now revert to the experiments in dhool separation conducted on the Multiple Sifter. Frequent changes in the sizes of mesh were made until eventually it was concluded that the best arrangement as far as we were concerned was:—

Upper Tray No. 5 Mesh.
Lower Tray Top or 1st Quarter No. 10, 2nd Quarter No. 8, 3rd Quarter No. 7, 4th Quarter No. 6 Meshes.

Two rollers were charged with 493 lbs. of withered leaf and rolling continued for six periods. The resulting dhools were:—

Over		No. 5 Mesh	72 lbs.	or	14·64%
No. 1 through		No. 10 ,,	111 ,,	,,	22·56%
,, 2 ,,		,, 8 ,,	61 ,,	,,	12·40%
,, 3 ,,		,, 7 ,,	93 ,,	,,	18·90%
,, 4 ,,		,, 6 ,,	50 ,,	,,	10·16%
Through ,, 5 over		,, 6 ,,	105 ,,	,,	21·34%

The figures given above are not an absolute instance, but have been closely duplicated on numerous occasions. It will be noted that the dhools under Nos. 1, 3 and 5 approximate to one another reasonably closely in weight, while the same can be said of Nos. 2 and 4, and tests showed that the grading was definite, and each even in itself.

These tests were conducted on the following lines. For clarity the finest grading through No. 10 Mesh is called No. 1; the next finest through No. 8 Mesh No. 2; through No. 7 — No. 3; through No. 6 — No. 4; over No. 6 — No. 5. A picture was taken of the grades in each of the five positions mentioned.

No. 1 comprised small even particles of leaf. (Plate I).

No. 2 contained slightly larger, with a few smaller particles (Plate II).

No. 3 was distinctly bolder and even. (Plate III).

No. 4 was very similar to No. 3. (Plate IV).

No. 5 was appreciably bolder, with some long stalks. (Plate V).

These dhools were fermented separately, and fired separately. Infusions were duly compared with our standard *par excellence* — that of the bud and first leaf manufacture.

The small even particles of No. 1 from the first roll compared even more favourably than we had expected. The infusion was exceptionally even and bright, and it was only on closer searching through a magnifying glass that an occasional duller, olive-green particle could be found. Our inference here was that as far as the first roll was concerned, the fall-through under No. 10 was chiefly composed of tip and first leaf.

Under No. 2, as was to be expected, dhools were slightly longer, though here too a fair percentage of smaller particles was found. Infusions were again even and bright.

No. 3 was distinctly bolder, but the infusions were still bright and even.

Infusions of No. 4 were also bright and even, but here a few duller particles of leaf were easily noticeable.

The bolder character of No. 5 resulted in a bright though mottled infusion.

The same method was applied to the second roll. The dhools closely approximated to the corresponding dhools from the first roll, but infusions were a shade less bright throughout, and an increased number of maturer particles was noticeable from No. 3 to No. 5.

This was followed on similar lines by the 3rd, 4th and 5th rolls, and in each of these it was easily noted that the infusions as the rolls progressed were each a shade inferior as regards brightness, though *evenness* was a distinct characteristic. From this we inferred that considerably greater *evenness* of fermentation could be effected by the separation of dhools into as many grades as is practicable.

Having concluded that for our purpose 5 dhool grades were necessary, steps were taken to ensure that, after our special grading of leaf particles, there should be no subsequent mixing or handling. For this purpose we eventually arrived at a series of superimposed trays, which slid into a suitably designed frame whioh was set beneath the lower tray of the sifter, to which minor additions had to be made to ensure dhools falling accurately on to the trays. Diagram I illustrates this.

The superimposition of all receptacles for leaf and/or dhools is necessary so that when the upper tray is removed leaf does not fall to the floor.

The type of tray is important, the reasons being:—

1. Cost.
2. Durability.
3. Lightness.
4. Suitability for fermentation.

Experiments carried out at the Tea Research Institute show that these trays can be constructed of either wood, asbestos, aluminium, or galvanised iron sheeting without any difference from a ferment on concrete being detected.

It was with reluctance that the idea of a mesh base had temporarily to be abandoned owing to our not having been able to find a suitable metal which would stand up to cleansing and rough handling, at a price which was not prohibitive. It is hoped eventually to overcome this difficulty, as it is thought that the circulation of the air under, as well as over, fermenting dhools may be beneficial. The benefit of such aeration has not yet been proved, but on the other hand it has also not been disproved. The Tea Research Institute has expressed willingness to investigate in this direction.

As it was intended that all dhool should receive a minimum of handling, it now became obvious to us that the trays could be fitted into suitably constructed racks, and thus become the fermenting table.

The most suitable size for these trays was found to be 4 feet by 18 inches by $2\frac{1}{2}$ inches, and this allows for a depth of leaf up to 2 inches during the period of fermentation. The frame beneath the sifter is fitted with the necessary strikers to level off dhools as trays are withdrawn prior to weighing and placing in position on the fermenting racks. 2 inches is of course an arbitrary height, and frames should be made higher or lower to suit conditions, or individual requirements. A tray of the size given holds approximately 15 lbs. of dhool.

In this method it will become at once apparent:—

1. That there can be no mixing of graded dhools.
2. That a more even ferment must follow.
3. That a large number of handlings of leaf have been avoided.

An additional advantage is that the leaf and dhool do not come into contact with any roll breaker or sifter parts that require lubrication, and, therefore, there is no possibility of contamination with oil. Further, the use of unhygienic absorbent jute hessian is avoided, and the drying out of dhools is reduced in consequence.

Once on the rack it now becomes a simple matter to judge the ferment of any individual tray of dhool, which can be removed *therein* to the drier, thus obviating yet another handling.

More hygienic methods of manufacture in the rolling room are long overdue, and similar superimposed trays under all roll breakers were found not only to keep leaf off the floor, and minimise handling, but also to accelerate the transport of dhools from the roll breaker to sifter.

The principle has also been extended to capturing all leaf passing over roll breakers, and the top tray of the sifter.

PLATE I.

Dhool I from No. 10 mesh

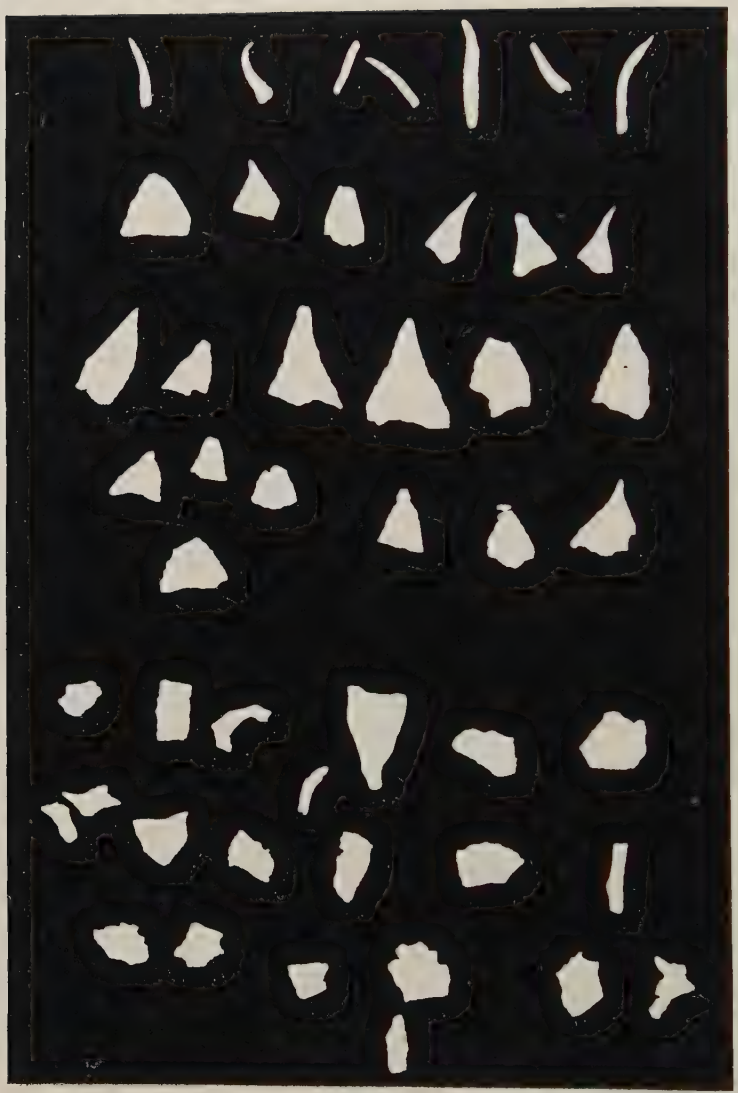

PLATE IV.

Dhool IV from No. 6 mesh

PLATE V.

Dhool V passing over No. 6 mesh

PLATE VI.

Leaf passing through No. 5 mesh in ordinary roll breaking

PLATE VII.

Leaf from No. 6 mesh in ordinary roll breaking

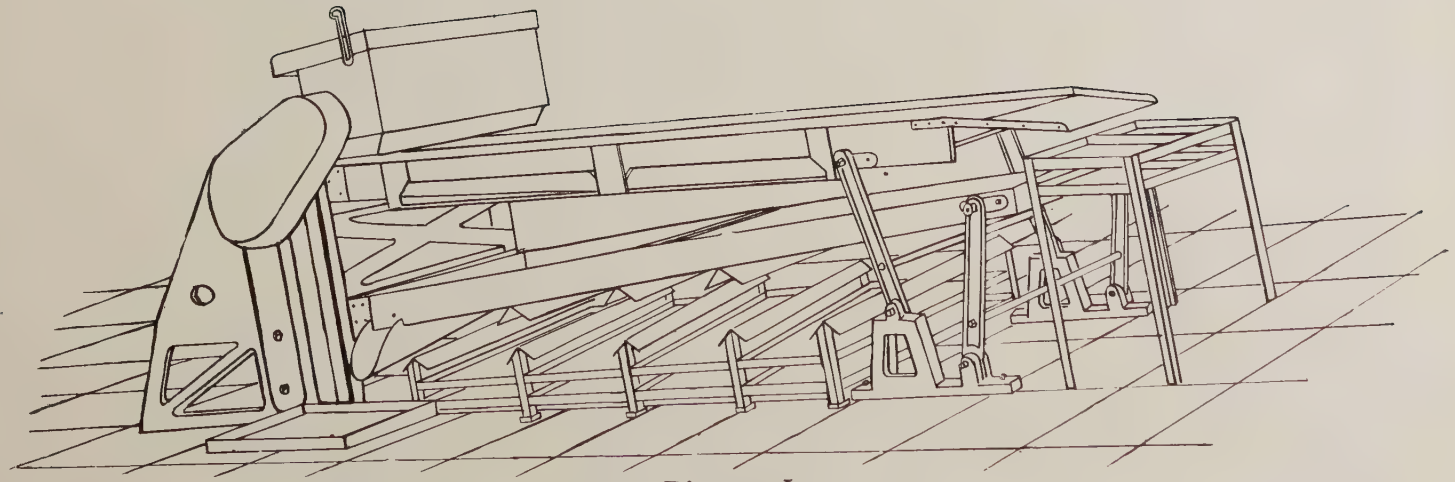

Diagram I.

All frames for holding trays under sifters and roll breakers should be so constructed as to render their removal at any time a simple matter, should it be found necessary to sweep underneath. In actual practice, however, this should be unnecessary if they are suitably designed.

It is regretted that these experiments had to be conducted in anything but a modern up-to-date factory, but we hope sufficient interest will be aroused for our modest start to be carried to greater lengths by those who are equipped with better facilities and modern machinery throughout.

It is claimed:—

1. That no great expense would be incurred in adopting the system.
2. That comparatively a very small quantity of leaf actually comes in contact with the factory floor.
3. That the tendency is towards a reduction of cooly labour.

Before concluding, a point I would wish to stress is that it is a great pity after all the grading that has been done in the green state that teas should be mixed again when firing. This is unavoidable at present, but where new factories are being planned it would appear thoroughly well worth while considering the idea of putting in several small firing machines with suitably designed chambers in order that each one could be fed by a similar grade of dhool.

This, however, in no way mitigates the value of the graded fermentation which has been undertaken. It should be possible for an expert teamaker to take each tray to the firing machine at the correct time, and, therefore, *each* tray in itself should have an even ferment. This cannot be lost, even though the intermixing of dhools under present conditions, is unfortunately unavoidable.

We wish to record our thanks to the Tea Research Institute for allowing Mr. Lamb to take the necessary pictures, and also to Mr. Whiteman of Messrs. Brown & Co., Ltd., and Mr. de la Mare of Messrs. the Colombo Commercial Co., Ltd. for their kind assistance over the construction of trays.

APPENDIX

J. LAMB

Mr. Francillon has invited me to add a few notes to the preceding paper with special reference to the plates showing the composition of the different dhools.

Rolling experiments have been in progress for some time at St. Coombs in the course of which methods of standardising and measuring the pressure, speed, and work done by the experimental rollers have been devised in order that the effect of these factors and of batten design on dhool production may be investigated.

In the course of this work it soon became evident that some means of obtaining a permanent record of dhool composition was required so that the result of different treatments could readily be compared.

Ultimately it was found that the most convenient way of doing this was to soak an average sample of the dhool in water until all the particles were completely untwisted. The fragments could then be sorted, mounted on paper and a blue print obtained as a permanent record. From such a print the evenness, or otherwise, of a dhool can immediately be seen, and during its production it is possible to trace the origin of many of the particles making up the dhool. The plates which follow and those included in Mr. Francillon's paper have been obtained in this way.

It is a matter of common experience that different parts of the flush require different conditions of fermentation, and unless such constitutents can be separated even infusions cannot be expected.

The ideal method would be to manufacture the bud and first leaf separately from the second leaf and stalk. This was tried out at St. Coombs and remarkably fine teas were obtained, evenness of infusion in both cases being a notable characteristic. This finding is confirmed by Mr. Francillon's full scale experiments. Unfortunately such a method is not economically feasible, and it is necessary to rely instead on more efficient sorting of the normal pluck during rolling.

In this direction Mr. Francillon, as his paper shews, has obtained very successful results, and the evenness of the dhool obtained by his method of working is strikingly shewn in Plates I to V.

Before commenting on these Plates it may be of interest to study Plates VIII, IX & X, made from a rolling experiment at St. Coombs which illustrates the way in which the flush breaks up during the first roll.

Plate VIII illustrates a sample of bulk removed from a roller at St. Coombs after it has been in operation for 10 minutes in the first roll. The pluck consisted of a bud and two leaves and was picked over before rolling to ensure that the material was as uniform as possible.

After 10 minutes we see that some breaking up has already occurred; there is one complete piece of flush on the right hand side, but in the majority of cases some of the finer parts have already been twisted off.

Plate IX illustrates the state of affairs obtaining after 20 minutes and Plate X the position at the end of the roll. In both cases a considerable amount of breaking up has occurred, a common feature being the removal of the upper halves of the leaves. The stalks are generally intact.

Plates VI and VII illustrate the separation usually obtained by ordinary methods of roll breaking. In considering all these Plates it should be realised that the dhool appears much more even than the illustration since for the latter the fragments of leaf have been unrolled. It is the twisted form which occurs in the actual dhools so that a comparatively large piece of leaf when tightly rolled may pass through quite a fine mesh. Bearing in mind our object of aggregating fractions of similar origin we see that this is not a disadvantage so long as fragments from the second leaf and stalk are separated from the remainder.

Plate VI illustrates dhool from a first roll which passed through the No. 5 mesh of an ordinary roll breaker in which, for some reason hard to understand, the larger mesh often comes before the finer No. 6 mesh. At the top of this plate we find buds. In the second

row, the second from the left, there is the top of a second leaf, but the other fragments are derived from the first leaf. Lower down there are a few pieces of stalk and at the bottom a collection of very small pieces which when fired would make fannings.

In Plate VII is a representation of material which passed over the No. 5 mesh, but fell through No. 6. At a glance we note that the average size is somewhat smaller and the sample is on the whole much more even. The top row is again buds, but it is difficult to explain why so many should have escaped falling through No. 5 mesh, though of course the whole of the material falling through No. 6 mesh should have passed through the No. 5, if the sifting had been thorough.

From these two illustrations it is quite evident that dhools from ordinary roll breakers consist of a mixture of leaf of widely varying sizes, which means that more sifting will be necessary for the dry tea besides producing the risk of failure to obtain adequate separation of material of different origin.

In Plate I, on the other hand, a marked evenness is evident; this illustrates the type of material which passes through the No. 10 mesh in Mr. Francillon's system after a first roll, and which is practically pure fannings when fired. In the ordinary process of roll breaking we find this in the material passing No. 5, as shown at the bottom of Plate VI.

Plate II shows the type of material passing No. 8 mesh of the green leaf sifter. This is very much bolder than the previous sample, a number of buds are seen in the top row and in the second row a collection of tops of first leaves.

Plate III is similar, but bolder than II. The material depicted passed No. 7 mesh.

Passing on to No. 6 mesh we come to Plate IV. This material is again very even and contains the tops of a number of rather larger leaves

PLATE VIII.

Leaf after 10 minutes' rolling, 1st roll

PLATE IX.

Leaf after 20 minutes' rolling, 1st roll

PLATE X.

Leaf at end of 1st roll

There are very few buds in the coarse material which passes over the No. 6 mesh and is shown in Plate V. At the bottom of the plate an accumulation of stalk will be seen.

Comparing Plates I to V with VI and VII illustrating the dhool from an ordinary roll breaker, there cannot be any doubt of the effect of "Green Leaf Sifting" by Mr. Francillon's process.

I wish to express my gratitude to Mr. F. J. Whitehead for valuable advice and practical help accorded at all stages of our work on rolling and sifting, and to Mr. Francillon for permitting me to co-operate in the production of these pictorial records.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 21-9-1935.

Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon held in the Ceylon Chamber of Commerce Rooms, Colombo, on Saturday, the 21st September, 1935, at 10-30 a.m.

Present.—Mr. James Forbes (Jnr.) (Chairman), the Hon'ble the Financial Secretary, Major J. W. Oldfield, C.M.G., O.B.E., M.C., Messrs, I. L. Cameron, R. P. Gaddum, J. D. Hoare, A. H. Reid, D. T. Richards, S. C. Bisset (Secretary), and by invitation Dr. Roland V. Norris (Director, T. R. I.) and Mr. A. K. Halliley (Acting Secretary, P. A. of Ceylon).

Absent.—The Director of Agriculture, Messrs. E. L. Fraser, and D. H. Kotalawala, M.S.C.

1. Notice calling the Meeting was read.

2. Minutes of the Meeting of the Board of the Tea Research Institute of Ceylon held on the 11th July, 1935, were confirmed.

3. BOARD OF THE T. R. I.

Members of the Board.—The Chairman welcomed back Mr. D. T. Richards, who had returned from leave. A vote of thanks was recorded to Mr. F. A. Bond for having acted as a member of the Board during Mr. Richard's absence.

L.C.P.A. Representative.—The Chairman announced that Col. T. G. Jayewardene, V.D., M.S.C., the Representative of the Low-Country Products Association on the Board automatically retired in accordance with the terms of Section 5 (2) of Ordinance No. 12 of 1925, and the L.C.P.A. had been requested to submit the name of their Representative.

Experimental Sub-Committee.—Announced that Mr. Richards resumed his seat on this Sub-Committee *vice* Mr. Bond, who had been acting for him.

4. FINANCE

The Statement of Accounts as at 31st July, 1935, was adopted without comment.

5. SENIOR SCIENTIFIC STAFF

The Chairman announced that he had received letters from Dr. T. Eden and Dr. F. R. Tubbs thanking the Board for the congratulatory messages sent them on the occasion of their having received their Doctorates.

Agricultural Chemist — Dr. T. Eden.—The Chairman said that Dr. T. Eden would be away from the 30th October, 1935 to the 8th December, 1935, at Tocklai, and he therefore recommended that Dr. F. R. Tubbs should act for Dr. Eden.

This was carried.

Plant Physiologist — Dr. F. R. Tubbs.—The Chairman announced that this Officer had returned from furlough and resumed duties on the 10th August, 1935.

6. JUNIOR STAFF, T.R.I.

Research Assistant, Department of Agricultural Chemistry.—The Board considered the various applications that had been submitted for this post, and decided to appoint Dr. J. G. Shrikhande as from the 1st December, 1935.

7. ST. COOMBS ESTATE

(a). *Acting Visiting Agent's Report.*—The Chairman said that a copy of this Report had been sent to each member of the Board under cover of Circular No. A.14/35, dated the 28th August, 1935.

Pruning.—The Board decided that the matter of lengthening the pruning cycle should be deferred until *after* the return of the permanent Visiting Agent, Mr. J. W. Ferguson.

Roads and Drains.—The Chairman announced that the Superintendent had been asked to make the necessary provision in the 1936 estimates for gradually improving the estate paths.

(b). *Membership of the C. E. P. A.*—The Board approved of St. Coombs Estate becoming a member of the Ceylon Estates Proprietary Association, the Chairman or his nominee to have voting power.

8. HALF YEARLY REPORTS OF THE SMALL-HOLDINGS OFFICERS

The Chairman announced that copies of the Half Yearly Reports, January-June, 1935, of the Small-Holdings' Officers stationed at Gampola and Baddegama had been sent to each member of the Board under cover of Circular No. A.16/35, dated the 6th September, 1935.

9. MINUTES OF THE MEETING OF THE EXPERIMENTAL SUB-COMMITTEE HELD ON THE 20TH JULY, 1935

The Chairman announced that copies of these Minutes had been sent to each member of the Board on the 19th August, 1935.

There were no comments on these Minutes.

10. WORKMEN'S COMPENSATION ORDINANCE

The Board sanctioned the annual premia payable on behalf of the Research and Estate Staffs of the Institute. All employees are now fully covered in accordance with the above Ordinance.

The Meeting terminated with a vote of thanks to the Chair and to the Ceylon Chamber of Commerce for the loan of their Board Room.

S. C. BISSET,
Secretary,
Tea Research Institute of Ceylon.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 26-10-35.

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon, held in the Ceylon Chamber of Commerce Rooms, Colombo, on Saturday, the 26th October, 1935, at 9-30 a.m.

Present.—The Acting Director of Agriculture (Dr. J. C. Hutson), Messrs. E. L. Fraser, R. P. Gaddum, J. D. Hoare, Major J. W. Oldfield, C.M.G., O.B.E., M.C., S. C. Bisset (Secretary) and by invitation Dr. Roland V. Norris (Director, T. R. I.).

Absent.—The Hon'ble the Financial Secretary, Messrs. James Forbes (Jnr.), C. E. Hawes, T. G. Jayewardene, V.D., M.S.C., D. H. Kotalawala, M.S.C., A. H. Reid, and D. T. Richards.

1. Notice calling the Meeting was read.

2. ACTING CHAIRMAN T. R. I.

The Meeting was to appoint an Acting Chairman to attend to routine work until such time as the Chairman was well enough to resume his duties.

Major Oldfield proposed and Mr. Hoare seconded that Mr. R. P. Gaddum be appointed Acting Chairman.

This was carried unanimously.

Mr. Gaddum proposed from the Chair that all business on the Agenda be postponed till the Meeting to be held on the 9th November, 1935, when it was hoped that Mr. James Forbes (Jnr.) would be sufficiently well to resume the duties of Chairman.

A vote of thanks was passed to the Ceylon Chamber of Commerce for the use of their Board Room.

S. C. BISSET,
Secretary,
Tea Research Institute of Ceylon.

MINUTES OF A MEETING OF THE BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON HELD 9-11-1935.

Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon, held in the Ceylon Chamber of Commerce Rooms, Colombo, on Saturday, the 9th November, 1935, at 10-00 a.m.

Present.—Mr. James Forbes (Jnr.) (Chairman, T. R. I.), the Hon'ble the Financial Secretary, the Director of Agriculture, Major J. W. Oldfield, C.M.G., O.B.E., M.C., Messrs, E. L. Fraser, R. P. Gaddum, C. E. Hawes, J. D. Hoare, D. H. Kotalawala, M.S.C., D. T. Richards, S. C. Bisset, (Secretary), and by invitation Dr. C. H. Gadd and Mr. A. K. Hallilеy (Acting Secretary, Planters' Association of Ceylon).

Absent.—Col. T. G. Jayewardene, V.D., M.S.C., and Mr. A. H. Reid.

1. Notice calling the Meeting was read.

The Chairman apologised to the Board for any inconvenience members might have been caused through his recent illness.

2. The Minutes of the Meetings of the Board of the Tea Research Institute of Ceylon, held on the 21st September and 26th October, 1935, were confirmed.

3. MEMBERS OF THE BOARD OF THE T.R.I.

The Chairman welcomed the Hon'ble Mr. H. J. Huxham on his return from furlough and recorded a vote of thanks to Mr. Collins for his services while acting for Mr. Huxham.

The Chairman also extended a welcome to Mr. C. E. Hawes and thanked him for having agreed to act during the short period of Mr. I. L. Cameron's absence as from the 19th October to the 13th November, 1935.

It was announced that the Low-Country Products' Association had nominated Col. T. G. Jayewardene, V.D., M.S.C., for a further period of three years as from the 25th September, 1935.

Acting Chairman, T.R.I.—A vote of thanks was recorded to Mr. R. P. Gaddum for having acted as Chairman of the Institute during Mr. James Forbes' illness.

4. FINANCE

Statement of Accounts as at 30th September, 1935.—A copy of which had been sent to each member of the Board on the 30th October, 1935, was adopted without comment.

5. SENIOR SCIENTIFIC STAFF

(a) *Director T. R. I. — Dr. Roland V. Norris.*—Announced that Dr. Norris was on sick leave and that Dr. Gadd was acting as Director as from the 29th October, 1935.

(b) *Agricultural Chemist — Dr. T. Eden.*—The Chairman stated that Dr. Eden had proceeded to Tocklai on the 30th October and that Dr. Tubbs was acting for him.

6. JUNIOR SCIENTIFIC STAFF

Research Assistant, Department of Agricultural Chemistry — Dr. J. G. Shrikhande.—Announced that this officer would be taking up duties as from the 1st December, 1935.

7. SECRETARY, T.R.I.

The Chairman announced that Mr. A. W. L. Turner would be returning to duty on the 20th November, and relieve Mr. S. C. Bisset, who had been acting for him as Secretary of the Institute.

The Chairman personally and in the name of the Board thanked Mr. Bisset for his services. He also thanked Mr. Halliley, Acting Secretary of the Planters' Association of Ceylon for his services.

S. C. BISSET,
Secretary,
Tea Research Institute of Ceylon.

NOTICES.

The Institute's Laboratories are situated at St. Coombs, Talawakelle, and all applications and enquiries should be addressed to the Director, Tea Research Institute, St. Coombs, Talawakelle.

Specimens and other consignments sent by rail should be forwarded to Talawakelle Station c/o Messrs. Hemachandra & Co., Forwarding Agents.

Visitors' Day.—The *last* Wednesday in each month has been set aside as Visitors' Day at St. Coombs Estate, when it is hoped anyone interested will visit the Station.

Visitors at other times are welcomed, but it is requested that an appointment be made if possible.

Publications.—Applications for the Institute's Publications should be directed to the Secretary, at Victoria Commemoration Buildings, Kandy, and *not to the Director's Office.*

ROLAND V. NORRIS,
Director.

INDEX.

	Page
Accessory foodstuffs	- 131
Address by the Chairman of the Board	- 4
Aeration of tea soils	- 178
Arancaria excelsa	- 103
Arancaria bidivellia	- 103
Artemisia vulgaris	- 107
Artificial Manures	10, 126
Betula acuminata	102, 103
Biophytum proliferum	- 108
Books on tea	77, 169
Bucklandia populaea	- 103
Bulk Manures	- 126
Capillary movement of water	- 27
Carbon-Nitrogen ratio	128, 152
Cardamine trichocarpa	- 107
Cardamine hirsuta	- 107
Cassia kleinii	- 108
Cassia leschennaultiana	- 109
Cassia mimosoides	- 108
Centella asiatica	- 108
Centroscma pubescens	- 108
Competition of shade trees	31, 36
Composts	11, 79, 100, 123, 151
Composts, costs of in Ceylon	- 158
Composts, effect on quality	13, 161
Conference of the Tea Research Institute	1, 4
Co-operation in Tea Research	- 18
Courses of instruction for Planters	- 7
Cultivation	- 177
Cultivation, effect of in drought	29, 32, 34, 180
Cultivation in relation to Green Manuring	- 180
Cupressus	- 103
Cut-across pruning	- 97
Desmodium heterophyllum	- 108
Desmodium triflorum	- 108
Deterioration of made tea	3, 62
Dhools, leaf analyses of	194, 199
Dieback after pruning	15, 93
Diseases of tea	19, 132
Drainage	- 30
Drought conditions in relation to tea culture	- 20
Dry weather pruning	- 23
Dryers, tests of	65, 76
Drying of tea, conditions for	- 53
Drying machines, efficiency of	- 48
Drying by exhaust steam	- 140
Drymaria cordata	- 109
Eucalyptus ficifolia	- 102
Eucalyptus globulus	- 102
Eucalyptus marginata	- 103
Eucalyptus pauciflora	- 102
Eucalyptus pilularis	- 102
Eucalyptus robusta	- 102
Factory design	- 17
Factories, use of steam in tea	- 147
Fermentation	192, 197
Finances of the Institute	- 4
Final Firing	- 61
Firing of tea	- 43
Firewood, supply for tea estates	- 101
Food reserves of tea	- 93
Foreign matter in tea	- 123
Fungi, characteristics of	- 134
Fungus diseases of tea	- 132
Glossary of tea tasters' terms	- 183
Green leaf sifting of tea	- 192
Green Manures	126, 153
Green Manures, composting of	13, 80
Green Manures in relation to drought,	34, 37, 38, 40, 41, 42
Green Manures, effect on quality	- 161
Grevilleas	- 103
Ground covers	- 107
Growth of young tea	- 87
Hedyotis monosperma	- 108
Humus	- 152
Hydrocotyle Javanica	- 109
Hygroscopic properties of tea	- 171

	Page
Indigofera endecaphylla	- 110
Inorganic Manures, effect of	10, 98, 126
Java, visit to	- 76
Justicia procumbens	- 109
Laurembergia wangerinii	- 108
Manganese in tea soils	- 91
Manufacturing experiments	16, 17, 169, 194, 199
Manures, availability of	- 127
Manures, comparison of inorganic and organic	- 10
Manures, effect on yield and quality	9, 98, 99
Manurial experiments	- 8
Manurial value of composts	- 83
Marshall's "New Empire" Dyrer, test of	65, 76
Minutes of the Meeting of the Board	72, 117, 163, 203, 206, 207
Moisture in tea	2, 172
Moisture, conservation of soil	- 30
Mulching	- 29
Nettle Grub, effect of pruning on	- 88
Nitrogen, recovery of soil nitrogen by tea	- 130
Nitrogenous manures, effects of	- 9
Non-parasitic diseases of tea	- 133
Organic manures	10, 98, 126
Oxalis corniculata	- 110
Oxalis corymbosa	- 109
Oxalis latifolia	- 109
Packing materials	2, 61
Packing of tea	1, 171
Parasitic diseases of tea	- 133
Parochetus communis	- 109
Paspalum dilatatum	- 110
Passara Sub-Station	16, 169
Phosphate manures, trials with	- 11
Physiological experiments	15, 85
Plantago lanceolata	- 108
Plucking rounds, length of	- 90
Potash, effect of	- 9
Potash reserves	- 97
Pruning experiments	14, 92
Pruning in relation to elevation	- 95
Pruning in relation to restriction	- 90
Pruning in relation to Nettle Grub	- 88
Pruning in relation to Tortrix	- 90
Pruning, rim-lung	- 15
Quality of tea, effect of composts on	13, 161
Quality of tea, effect of manures on	9, 88, 130
Quality of tea, factors affecting	99, 100
Ranunculus Wallichianus	- 108
Recovery from pruning	14, 92
Red gum, use for firewood	- 104
Resistance of plants to fungus diseases	- 138
Resting of tea	- 90
Restriction, estate programme in	90
Rim-lung pruning	15, 92
Rolling experiments	17, 169, 194, 199
Rolling, disintegration of flush during	- 200
Root damage	- 182
Root development	- 178
Root system in relation to drought	- 45
Seed, treatment of tea	- 87
Selection work in tea	- 86
Shade Trees, competition by	31, 41
Shot-Hole Borer	- 168
Sifting of tea	- 192
Small-Holdings, reports on	111, 113
Small-Holdings, competition	- 124
Soil Aeration	- 178
Stoves, drying, details of	- 44
Steam, use of in tea factories	- 147
Storage of tea	- 171
Stripping in relation to drought	24, 35
Sulphur taints	- 187
Sun drying of tea	- 64
Supplying, treatment of stumps	- 88
Syncarpia laurifolia	- 103
Taints, sulphur	- 187
Tea chest linings	1, 175
Tea, cultivation of	- 177

	Page
Tea, deterioration of	- 3
Tea, drying of	- 43
Tea extracts	- 76
Tea factories, use of steam in	- 147
Tea, fermentation of	192, 197
Tea, foreign matter in	- 123
Tea, green leaf sifting of	- 192
Tea, growth of	- 87
Tea, hygroscopic properties of	- 171
Tea, manufacture of	16, 43, 169
Tea, moisture content of	2, 61
Tea, packing of	1, 171
Tea Research	- 85
Tea, resting of	- 90
Tea selection	- 86
Tea soils	- 169
Tea, storage of	- 171
Tea, water requirements of	- 21
Tea, wilting of	- 39
Tea tasters' terms	170, 183
Test of Marshall's "New Empire" Dryer	- 65
Torenia cyania	- 109
Trays for roll-breakers	- 196
Trichogramma, further trials with	- 140
Trichogramma, distance flown by	- 142
Trichogramma, life cycle of	- 145
Triflorum subterraneum	- 109
Tortrix, effect of pruning on	- 90
Tortrix, effect of egg-mass collection	- 89
Tortrix, effect of *Trichogramma* on	- 140
Tortrix, spraying against	- 98
Transpiration	- 22
Vegetative propagation	- 86
Virus diseases	- 133
Water and the plant	- 20
Water distribution in the soil	- 27
Weeds	- 178
Witches' Broom	- 19
Withering experiments	- 16

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THE

TEA QUARTERLY

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THE JOURNAL

OF THE

TEA RESEARCH INSTITUTE

OF CEYLON.

Edited by

ROLAND V. NORRIS, D.Sc., F.I.C.,

Director, Tea Research Institute.

THE TEA RESEARCH INSTITUTE.

St. Coombs, Talawakelle.

PRINTERS H. W. CAVE & CO., COLOMBO.

The Tea Research Institute of Ceylon.

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CONTENTS.

		Page
1.	Editorial	1
2.	Proceedings of the Fourth Conference of the Tea Research Institute of Ceylon:—	
	(a). Forbes (Jnr.) James—Address ...	4
	(b). Norris, R. V. —Review of the Institute's Programme of Work ...	7
	(c). Drought Conditions in Relation to Tea Culture:—	
	(I) Gadd, C. H.—Water and the Plant ...	20
	(II) Eden. T.—The Soil as a Water Reservoir	27
	(III) Discussion	33
	(d). Discussion on Manufacture:—	
	(I) Lamb, J. —The Theory and Practice of Tea Drying ...	43
	(II) Discussion	61
3.	Lamb, J.—Report on Test of a Marshall's New "Empire" Tea Dryer ...	65
4.	—— Notices.	71
5.	—— Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held on December 11, 1934.	72

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CONTENTS.

		Page
1.	Editorial	75
2.	Eden, T.—Compost Manufacture and Use on Tea Estates.	79
3.	Tubbs, F. R.—Tea Research in Ceylon ...	85
4.	King, H. C.—Note on the Supply of Firewood for Tea Estates	101
5,	Wilkinson, C. H.—Ground Cover on a Dimbula Estate	107
6.	—— Half-Yearly Reports of the Small-Holdings Officers, Gampola and Baddegama	111
7.	—— Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held on 15th March, 1935 ...	117
8.	—— Notices	121

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(7) Vacant.

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CONTENTS

		Page
1.	Editorial	122
2.	Eden, T.— Organic and Inorganic Manures ...	126
3.	Gadd, C. H.—Diseases of the Tea Bush—I. Diseases in General and Fungi in Particular	132
4.	King, C. B. R.—A Further Trial with Trichogramma	140
5.	Ridler, W. F. A..—The Use of Steam in Tea Factories	147
6.	Eden, T.— Report on Composting in Relation to Tea Cultivation	151
7.	—— Minutes of a Meeting of the Board of the Tea Research Institute of Ceylon held on the 11th July, 1935 ...	163
8.	—— Notices	166

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Edited by

ROLAND V. NORRIS, D.Sc., F.I.C.,

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THE TEA RESEARCH INSTITUTE,

St. Coombs, Talawakelle.

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The Tea Research Institute of Ceylon.

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CONTENTS.

		Page
1.	Editorial	168
2.	Lamb, J.—The Storage and Packing of Tea ...	171
3.	Eden, T.—The Cultivation of Tea	177
4.	Bradshaw, R. G. and Yuille, H. B.—A Glossary of Tea Tasters' Terms...	183
5.	Lamb, J.—Sulphur Taints	187
6.	Francillon, F. R.—Notes on Green Leaf Sifting and Fermentation	192
7.	—— Minutes of Meetings of the Board of the Tea Research Institute of Ceylon, held on the 21st September, 26th October, and 9th November. 1935 ...	203
8.	—— Notices	209

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